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Thirty Years of Minimally Invasive Colorectal Surgery at the Fundeni Clinical Institute: An Institutional Experience

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Rezumat

Treizeci de ani de chirurgie colorectală minim invazivă în Institutul Clinic Fundeni: Experiența unei instituții

Introducere: Chirurgia colorectală minim invazivă a cunoscut o evoluție semnificativă în România în ultimele trei decenii, deşi adoptarea inițială a fost lentă şi neuniformă în multe centre. La Institutul Clinic Fundeni, această evoluție a început în 1995, odată cu prima intervenție colorectală laparoscopică raportată în România, marcând debutul unei tranziții progresive de la abordul deschis către chirurgie minim invazivă, atât pentru patologia colonică, cât şi pentru cea rectală.
Metode: Am realizat o analiză retrospectivă instituțională, integrând repere istorice, experiența publicată şi analiza bazelor de date interne. Au fost evaluate tehnicile laparoscopice, robotice, inclusiv abordul transanal, cu accent pe chirurgia oncologică colorectală şi pe extinderea progresivă a indicațiilor minim invazive.
Rezultate: După o perioadă inițială de diseminare prudentă şi limitată, chirurgia colorectală minim invazivă s-a extins progresiv odată cu creşterea experienței chirurgicale şi a resurselor tehnologice. Introducerea unor proceduri laparoscopice avansate, inclusiv reversia laparoscopică a operației Hartmann si tehnici variate cu abord transanal, a reflectat extinderea practicii minim invazive colorectale dincolo de cazurile selectate, către cazuri colorectale mai complexe. În perioada 2012–2023 au fost efectuate 2.447 de rezecții pentru cancer rectal, dintre care 446 prin abord minim invaziv. După întreruperea programului robotic, chirurgia laparoscopică a reprezentat singura metodă minim invazivă şi a fost, în mod paradoxal, asociată cu o creştere suplimentară a numărului de intervenții minim invazive, în ciuda absenței chirurgiei robotice, fără a compromite rezultatele oncologice sau postoperatorii.
Concluzii: Experiența Institutului Clinic Fundeni ilustrează maturizarea reuşită a chirurgiei colorectale minim invazive, de la o etapă incipientă, de pionierat, la o practică stabilă şi în continuă expansiune. În pofida limitărilor inițiale şi a întreruperii programului de chirurgie robotică, chirurgia laparoscopică a devenit principalul element catalizator al procedurilor minim invazive, permițând extinderea acestora către cazuri mai complexe, fără a compromite rezultatele oncologice sau perioperatorii. Această evoluție evidențiază rolul institutului în consolidarea chirurgiei colorectale minim invazive ca standard consacrat într-un centru cu volum mare de activitate.

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Cuvinte cheie: chirurgie minim invazivă, chirurgie colorectală laparoscopică, cancer rectal, chirurgie robotică, experiență instituțională

Abstract

Background: Minimally invasive colorectal surgery has evolved considerably in our country over the past three decades, although its early adoption was slow and uneven in many centers. At the Fundeni Clinical Institute, this evolution began in 1995 with the first reported laparoscopic colorectal operation performed in Romania, marking the start of a gradual transition from the open approach to minimally invasive surgery for both colonic and rectal pathology.

Methods: We conducted a retrospective institutional review, integrating historical milestones, published experience, and analysis of internal databases. Laparoscopic, robotic-assisted, and transanal techniques were evaluated, with emphasis on oncologic colorectal surgery and the progressive expansion of minimally invasive indications.

Results: After an initial period of cautious and limited dissemination, minimally invasive colorectal surgery progressively expanded as surgical expertise and technological resources improved. The adoption of advanced laparoscopic procedures, including the laparoscopic reversal of the Hartmann procedure and various transanal techniques, reflected the extension of minimally invasive colorectal practice beyond selected cases, to more complex colorectal surgery. Between 2012 and 2023, 2,447 rectal cancer resections were performed, of which 446 were minimally invasive. After discontinuation of the robotic program, laparoscopic surgery served as the sole minimally invasive approach and was paradoxically associated with a further increase in minimally invasive procedures, despite the absence of robotic surgery, without compromising oncologic or postoperative outcomes.

Conclusions: The experience of the Fundeni Clinical Institute illustrates the successful maturation of minimally invasive colorectal surgery from an early pioneering stage to a stable and expanding practice. Despite initial limitations and the discontinuation of the robotic program, laparoscopic surgery became the main driver of minimally invasive procedures, enabling their extension to more complex cases without compromising oncologic or perioperative outcomes. This evolution highlights the institute's role in consolidating minimally invasive colorectal surgery as a reliable standard in a high-volume center.

Keywords: minimally invasive surgery, laparoscopic colorectal surgery, rectal cancer, robotic-assisted surgery, oncologic outcomes, institutional experience

Introduction

Laparoscopic surgery has its origins at the beginning of the 20th century, when it was initially performed experimentally in animal models and subsequently used exclusively for diagnostic purposes (1).

Progressive developments in endoscopic instrumentation and gynecologic surgery paved the way for the introduction of laparoscopic techniques into general surgery, culminating in Erich Mühe's first laparoscopic cholecystectomy in September 1985 (2). Initially, Erich Muhe's work was surrounded by failure, criticism, and skepticism, yet he thrived and managed to become a pioneer of minimally invasive digestive surgery and the protagonist of inspirational narratives that remain relevant even five decades later.

In the early 1990s, the American surgeon Moises Jacobs performed the first laparoscopic right hemicolectomy (3). Following early adoption, laparoscopic colorectal surgery emerged as an alternative to open techniques due to its reduced physiological impact (3). Open surgery, while effective, is associated with well-known limitations, including increased and prolonged postoperative pain, larger incisions that may negatively affect psychological status and patient cooperation, and greater blood loss. In contrast, laparoscopy minimizes abdominal wall trauma, enabling faster recovery, earlier bowel function return, and shorter hospital stay, with comparable safety in experienced hands (3). These advantages supported the transition from routine open colorectal surgery to minimally invasive approaches. However, laparoscopy does not modify core oncologic principles, but it represents an alternative access route, requiring the same strict adherence to standards of radical oncologic resection.

Consistent with this view, both the ESMO (European Society for Medical Oncology) and NCCN (the National Comprehensive Cancer Network) guidelines recognize minimally invasive approaches as oncologically acceptable alternatives to open surgery in colorectal cancer, provided that established oncologic

principles are strictly respected (4-7). In rectal cancer, total mesorectal excision must be performed according to standard criteria, with careful attention to circumferential and distal margins; additionally, in selected patients achieving a clinical complete response after neoadjuvant therapy, a non-operative ("watch-and-wait") strategy may be considered, as will be discussed later (5,7). In colon cancer, laparoscopic colectomy is regarded as safe in the absence of contraindications when adequate oncologic resection and lymphadenectomy are ensured (4,6). Overall, current evidence supports minimally invasive surgery (MIS) as a safe and oncologically equivalent approach for both colon and rectal cancer when performed by experienced teams (4-7).

Within a single year, colorectal surgery underwent such a drastic transformation that the majority of procedures became feasible through minimally invasive approaches - a paradigm shift that soon became standard practice worldwide. In China, the first laparoscopic colorectal procedure was performed in 1993 (3), while in Romania this milestone was achieved only two years later (8).

This article aims to describe the evolution of minimally invasive colorectal surgery at the Fundeni Clinical Institute (ICF) over the past three decades, a setting in which multiple techniques were pioneered, refined, and adapted in the face of significant challenges.

Introducing Change: Early Steps in Laparoscopic Surgery

The dissemination of laparoscopic colorectal surgery was slow, and its widespread adoption encountered numerous doctrinal, infrastructural, and cultural barriers, challenges that were also present in our institution (9). Nevertheless, these obstacles were met with perseverance.

On July 5, 1995, at the Fundeni General Surgery Clinic, a laparoscopic abdominoperineal resection was performed on a female patient diagnosed with low rectal cancer (8). The case was reported in the national journal "Chirurgia" and thus became the first published laparoscopic colorectal surgical procedure in Romania (8).

In 1998, the first national laparoscopic anterior resection of the rectum took place at ICF, a procedure that is technically more demanding than an abdominoperineal resection (10). The reported case involved a 63-year-old female patient with a rectal tumor located 9 cm from the anal verge (10). Postoperative recovery was rapid and uneventful, with bowel function restored within 48 hours and discharge on postoperative day six, reflecting the growing interest in laparoscopic surgery in Romania (10).

The introduction and availability of specialized medical equipment in Romania, including advanced vessel-sealing devices, ultrasonic energy-based instruments, and modern linear and circular stapling systems, represented a major step toward aligning surgical practice with European standards.

In parallel with the development of laparoscopic surgery, sustained efforts were directed towards improving other techniques, particularly functional reconstructive procedures in rectal cancer surgery. Between 1998 and 2003, rectal resections with coloanal anastomosis and colonic J-pouch reconstruction were performed at the Department of General Surgery and Liver Transplantation of the ICF (11). These cases were reported in the Romanian surgical literature as a series of seven patients, with favorable outcomes, reaffirming the constant concern for quality of life in oncologic patients (11).

Contrary to initial expectations, laparoscopy in colorectal surgery was not adopted as rapidly as anticipated after its early achievements. Instead, its dissemination was characterized by sustained hesitation and resistance within the surgical community, leading to very limited uptake over the following decade, with only a few isolated cases performed and a delayed advancement of minimally invasive colorectal surgery in Romania (12).

These factors were further compounded by the limitations of scientific evidence, characterized by inconclusive studies or limited statistical power, highlighting the need for larger patient cohorts and robust results consistent with the principles of evidence-based medicine (12).

Reflecting on his own scientific career, Max Planck noted, somewhat pessimistically, that "A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it" (13). In medicine, change does not always depend solely on the quality of evidence, but also on the willingness of others to take it into consideration with an open-minded perspective. Sometimes the evidence we need is already available, but it only becomes truly convincing when there is a willingness to see it and to abandon what we already know.

For a long time, these procedures remained confined to a few isolated expert teams. Wider clinical application emerged once the technique began to be adopted and mastered beyond this initial group.

From Laparoscopy to Robotic Surgery – or is it the Other Way Around?

More than 60 years ago, in Western countries, telemedicine was being developed. Initially, it was only used for applications in space and military medicine, but later it led to the development of a robotic telemanipulation system for microsurgery at the Stanford Research Institute (14).

In 1985, a pioneering device was used for the first time worldwide to obtain biopsies in the field of neurosurgery (14).

Robotic surgery represents an advanced extension of MIS, offering three-dimensional visualization, motion scaling, tremor filtration, and improved ergonomics through articulated instruments (14). While laparoscopy has significantly contributed to MIS, it is still hampered by counterintuitive instrument manipulation, two-dimensional vision, limited degrees of freedom, and poor ergonomics, especially in anatomically restricted areas such as the pelvis (15). Robotic surgery emerged as a response to these limitations; however, despite its technical advantages, its broader implementation remains limited by important factors, including the absence of tactile feedback, restricted intraoperative flexibility, and high overall costs related to platform acquisition, maintenance, training, and prolonged operative times during the learning curve (14).

In 2008, the da Vinci S robotic system was introduced at the Department of General Surgery and Liver Transplantation of the ICF (16). Between 2008 and 2009, a total of 3,909 surgical procedures were performed at our institution, of which 547 were minimally invasive (16). Among these, 153 patients underwent robotic-assisted surgery, encompassing a broad spectrum of abdominal and thoracic procedures. The majority were abdominal interventions, including upper gastrointestinal surgery, hepatobiliary and pancreatic procedures, splenic surgery, gynecologic oncologic procedures, and colorectal resections. Colonic and rectal resections accounted for 29 cases, reflecting the early integration of robotic techniques into colorectal surgery at our center (16).

In a comparative institutional series published in 2010 which included 84 laparoscopic and 38 robotic rectal cancer resections, results were as follows: operative time was longer for the robotic approach, but intraoperative blood loss was lower (17). Postoperative complication rates were similar, including comparable anastomotic leak rates (17). Resection margins were negative in all patients and local recurrence occurred in 5.2% of robotic cases and 5.9% of laparoscopic cases during follow-up (17). Taken together, these results suggested that the robotic approach is an oncologically-safe alternative to laparoscopy, supposedly allowing a more refined dissection (17).

At a time when the literature reported very few cases of robot-assisted anterior pelvic exenteration and only a single case of totally robotic total pelvic exenteration worldwide up to 2011 (18), members of the ICF performed, to our knowledge, the second worldwide reported entirely robotic total pelvic exenteration for recurrent endometrial cancer (18).

Another institutional report of the first 100 consecutive robotic rectal cancer resections (2008–2012) confirmed the feasibility and oncologic safety of the robotic approach, reporting low conversion rates, 30% overall morbidity, and a 3-year overall survival of about 90% (19). Despite all of these achievements, after approximately ten years, the robotic program at the ICF was discontinued (20).

However, development continued beyond this point.

An important step in consolidating minimally invasive colorectal surgery at our center was the adoption of laparoscopic reversal of the Hartmann procedure, evaluated in a study highlighting the technical challenges, patient selection criteria, and potential benefits of this approach (21). This step was particularly significant, given that the laparoscopic Hartmann reversal is widely regarded as a major and technically demanding operation, burdened by high morbidity and mortality rates and considered one of the most complex procedures in colorectal MIS (22), and that fewer than 20% of reversals are attempted using minimally invasive techniques, making careful patient selection essential (21).

Despite continuous developments, rectal oncologic surgery remains a major challenge for surgeons worldwide. Total mesorectal excision represents the cornerstone of rectal cancer surgery, largely determining local recurrence rates and disease-free survival. Camran Nezhat, a pioneer of video-laparoscopy and an innovative laparoscopic surgeon, stated that wherever a cavity exists or can be created, laparoscopy is indicated and likely preferable, with the true limitation being surgical competence and the availability of appropriate instrumentation (23). However, although laparoscopic and robotic approaches provide superior visualization of the pelvic space compared to open surgery, this advantage alone might not be sufficient to overcome the inherent technical difficulties of mesorectal dissection, which begged the question… how can visualization be further improved? (24)

In Romania, a response to these limitations emerged on April 4, 2019, with the introduction of transanal total mesorectal excision (TaTME) in our center (25). The initial case involved a 65-year-old

female patient diagnosed with moderately differentiated adenocarcinoma of the mid-rectum, staged cT2N0M0 (25). Subsequently, TaTME became part of routine practice, with expanding indications as the surgical team progressed along the learning curve (25).

Institutional experience also confirms that MIS represents a safe and effective option for abdominoperineal resection, with reduced morbidity and satisfactory oncologic outcomes, while emphasizing the importance of appropriate patient selection and the need for further refinement of indications (24). This conclusion is supported by a 12-year comparative institutional study that evaluated abdominoperineal resections performed through open, laparoscopic, and robotic approaches in patients with low rectal and anal canal cancer, showing comparable oncologic radicality across techniques and a consistent perioperative advantage for MIS, particularly in terms of blood loss and postoperative morbidity, with the robotic approach demonstrating technical feasibility even in complex pelvic cases (24).

During the early years of the analyzed period (*Fig. 1*), a relatively stable percentage is observed, which can be explained by the availability of a functional robotic, contributing significantly to the overall volume of minimally invasive procedures. After 2018, following the discontinuation of the robotic system, laparoscopy became the primary minimally invasive approach, with surgical teams rapidly adapting and taking over cases that had previously been performed robotically.

Moreover, in recent years, the proportion of laparoscopic procedures not only compensated for the absence of the robotic platform but significantly exceeded previous levels, reaching approximately 30% after 2022

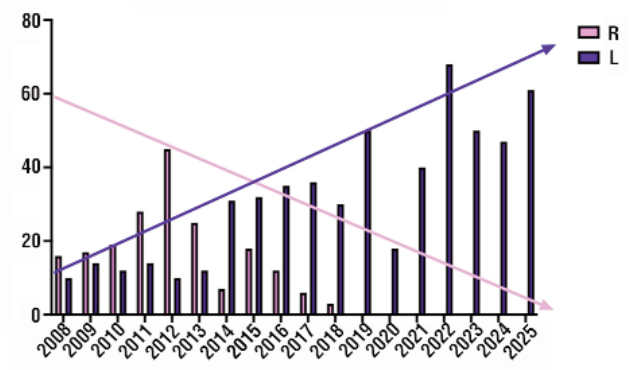

Figure 1. Trends in minimally invasive rectal cancer resections between 2008 and 2025. Pink bars represent robotic-assisted rectal resections (R), while blue bars represent laparoscopic rectal resections (L). Trend lines illustrate the decreasing use of robotic surgery and the progressive adoption of laparoscopic techniques over the study period. Data were obtained from the institutional database of Fundeni Clinical Institute.

(26). These data indicate that, although the robotic system was replaced by conventional laparoscopic instruments, surgical outcomes were not compromised; on the contrary, they continued to improve.

Selection of the Approach

In colorectal cancer surgery, the open approach remains particularly advantageous in technically complex cases, as it provides direct tactile feedback, wide exposure of the operative field, and unrestricted maneuverability, facilitating vascular control and dissection in advanced tumors or challenging anatomical situations (27), which are particularly useful in bulky T4 tumors with adjacent organ invasion (28).

However, in appropriately selected patients, minimally invasive techniques are generally preferred, as they preserve oncologic adequacy while effectively reducing many of the postoperative and recovery-related drawbacks inherent to open surgery.

Since the introduction of MIS, the learning curve has represented one of the greatest challenges for surgeons. A study published in 2001 reported that approximately 30 procedures are required for a surgeon to overcome the learning curve and achieve competence in laparoscopic colorectal resections (29). Furthermore, a study conducted among early-career American surgeons showed that many lacked confidence to independently perform laparoscopic colorectal procedures due to insufficient experience acquired during training (30).

There is a broad consensus that the learning curve for robotic surgery is shorter than that for laparoscopic surgery; however, robust data to unequivocally support this assumption remain limited (30). Simulation studies have demonstrated greater time advantages for more complex tasks, such as intracorporeal knot tying (30). This observation is reflected in clinical studies, where total mesorectal excision has been performed more rapidly using a robotic approach, while no significant differences in operative time were observed for splenic flexure mobilization or inferior mesenteric artery ligation (30). Contrary to common perception, robotic surgery may be associated with shorter operative times compared to laparoscopy when surgeon experience is comparable (30).

The advantages of robotic platforms appear to be most pronounced in complex procedures and during the early phases of the learning curve (30). This may be attributed to superior baseline performance rather than to a truly shorter learning curve, as previously suggested, and may translate into enhanced patient safety when surgeons are at the beginning of their experience (30). It remains to be determined whether

any potential acceleration of the laparoscopic learning curve persists sufficiently for acquired skills to ultimately surpass the performance offered by robotic systems.

These limitations help explain why, despite remarkable technological progress, MIS cannot be regarded as a universally applicable solution in rectal cancer. The indication for laparoscopic or robotic surgery must be individualized and established in experienced centers, with the primary objective being correct oncologic excision. In real-world clinical practice, there will always be a subset of patients for whom open surgery remains the safest and most appropriate approach. Ultimately, the value of the surgeon lies not in performing MIS per se, but in selecting the most appropriate approach for each individual patient.

Rethinking the Role of Surgery in the Future of Cancer Care

In the past, the vast majority of rectal cancer cases were treated by abdominoperineal resection. Currently, not only has the spectrum of cases suitable for organ-preserving surgery expanded, but multiple sphincter-preserving options have also become available. Local excision techniques, such as transanal minimally invasive surgery (TAMIS), were introduced in 2010 (31) as an improvement of transanal endoscopic microsurgery (TEM), originally described by Professor Buess in 1984 (32). Four decades later in Barcelona, the TaTME technique emerged as a natural convergence of transanal and MIS (33).

Over the past two decades, considerable attention has been directed toward conservative management strategies for rectal cancer (34). The concept of "watch-and-wait" was first introduced in 2004 (34) by Habr-Gama and colleagues, subsequently refined and consolidated in studies published in 2006 and 2009 (35,36). Trials such as OnCoRe (37), RAPIDO (38), and OPRA (39) provide supportive evidence for this strategy. It goes without saying that this approach cannot be applied universally and requires careful patient selection and a rigorous, well-established follow-up program.

The pertinent question therefore arises - will surgery continue to represent the standard of care across all oncologic settings?

Although not directly related to colorectal cancer, the experience in the treatment of cervical cancer offers a major example of the consequences of adopting new surgical techniques without sufficient oncologic validation. The LACC trial (40) and subsequent analyses (41) demonstrated that minimally invasive radical hysterectomy is associated with higher recurrence rates and inferior overall survival compared with open surgery. These findings led to a significant downgrading of laparoscopic and robotic approaches in this field and a return to open surgery as the therapeutic standard (40,41). This represents an important lesson that should not be overlooked.

In parallel with the evolution of surgical and oncologic strategies, advances in molecular biology and tumor immunology have also had a major impact on the treatment of colorectal cancer. Recent studies have highlighted the particular role of high microsatellite instability (MSI-H) and mismatch repair deficiency (dMMR) in determining tumor sensitivity to immunotherapy (7). Targeted immunotherapy against the PD-1 receptor has been shown to be highly effective in these settings, achieving significant rates of complete clinical response in locally advanced rectal cancer. Despite these promising results, the optimal follow-up strategy for such patients has not yet been fully defined (7).

Conclusions

Following colorectal cancer surgery, patients' primary expectations include prolonged survival, particularly long-term disease-free survival, a minimal likelihood of permanent colostomy, and limited-to-no impact on urinary and sexual function, while preserving a good quality of life. Within this framework, and considering the a large patient population with a wide spectrum of pathology, the activity of an academic center such as the Clinical Institute unfolds in a complex environment shaped by multiple pressures, including competition with private healthcare, media and commercial influences, challenges within the academic medical system, and, at times, administrative or political interference.

Laparoscopic and robotic surgery should be regarded as tools of oncologic surgery rather than objectives in themselves; their value depends on the surgeon's ability to employ them when appropriate and to abandon them when oncologic radicality may be compromised. The surgical robot should not be viewed as a "sophisticated laparoscope," but as a valuable instrument in selected situations. In spite of the drive for continuous improvement that characterizes the surgical field, the modern surgeon must also maintain strong ethical standards, ensuring that therapeutic decisions remain medically and oncologically sound rather than driven by external context.

Author's Contributions

Conceptualization, IMI and CEM; Methodology, CV;

Writing-review and editing, IMI and CEM; Supervision, CV. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

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