**UNIVERSITY OF MEDICINE AND PHARMACY**

**"CAROL DAVILA", BUCHAREST**

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**FIELD OF MEDICINE**

# MODIFIED ERAS PROTOCOL FOR PATIENTS WITH OCCLUSIVE COLORECTAL CANCER

## SUMMARY OF DOCTORAL THESIS

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## Introduction

Colorectal cancer (CRC) is a major cause of morbidity and mortality worldwide. It is the second leading cause of cancer-related death in both sexes in Europe, following lung cancer, and affects approximately 1 in 20 individuals in developed countries. In our country, the incidence of colorectal cancer has doubled over the past 25 years [2]. The distribution by sex shows a higher incidence in men (M:F = 1.5 in Romania), and the distribution by age group reveals an increased incidence in patients over 50 years old (accounting for 90% of cases), with a peak in the seventh decade of life [3].

The diagnosis of intestinal obstruction is based on clinical history and physical examination. Symptoms typically include diffuse or nonspecific abdominal pain, vomiting, abdominal distension, and cessation of bowel movements. Plain abdominal radiography reveals characteristic hydro-aeric levels, while computed tomography (CT) accurately identifies the site of obstruction. The gold standard for diagnosis is contrast-enhanced abdominal CT, which is recommended for all suspected cases of acute abdomen or bowel obstruction [3]. Although many cases of intestinal obstruction require emergency surgery, initial volemic resuscitation is mandatory for all patients prior to surgery. Given that patients with intestinal obstruction are often critically ill, resuscitation depends on the type of obstruction and the severity of metabolic and hemodynamic disturbances. Fluid management should be adjusted according to clinical response, with monitoring of central venous pressure (CVP), blood pressure (BP), and urine output.

Patients undergoing emergency surgery for bowel obstruction may represent some of the most challenging cases encountered by anesthesiologists in general surgery. The anesthetic management includes: (i) rapid sequence induction and orotracheal intubation; (ii) maintenance of anesthesia and monitoring of anesthetic depth; (iii) temperature management and prevention of hypotension; (iv) pulmonary ventilation strategies; (v) monitoring and reversal of neuromuscular blockade; (vi) hemodynamic support including vasopressor use; (vii) blood glucose control and transfusion management; (viii) emergence from anesthesia and extubation; (ix) prevention of postoperative pulmonary complications; (x) analgesic techniques adjunct to general anesthesia, including neuraxial (epidural/spinal) blocks, non-neuraxial blocks (transversus abdominis plane or rectus sheath), and local infiltration techniques; and (xi) postoperative admission to the Intensive Care Unit (ICU).

From the point of view of surgical treatment, bowel occlusions due to colorectal cancers generally represent a delayed or even postponed emergency. The delay is due to the need to establish a preoperative etiologic diagnosis and to initiate general hydro-

electrolyte rebalancing treatment. On the other hand, the delay of surgery may be aimed at realizing a therapeutic plan in which the intestinal occlusion and the colorectal tumor are addressed concomitantly or consecutively. Such a plan makes it possible to implement some of the principles of ERAS, with the aim of lowering operative stress and improving patient recovery.

For resectable colorectal cancer complicated by clinically and radiologically evident bowel obstruction, there are several surgical approach options:

1. One-stage colectomy with en bloc removal of the regional lymph nodes followed by restoration of digestive continuity by anastomosis (for some right colon lesions) or by performing a colostomy or ileostomy;

2. External bypass (ostomy) or stenting (in selected cases) for the purpose of decompression, followed by colectomy with or without restoration of digestive continuity; stents are generally reserved for distal lesions, where they may allow decompression of the proximal colon followed by subsequent elective colectomy with primary anastomosis.

## ERAS PRINCIPLES IN THE TREATMENT OF OBSTRUCTIVE COLORECTAL CANCER (CRC)

### History and Premises of the Implementation of ERAS Protocols

The concept dates back to the 1990s and started with elective colorectal surgery. Prof. Henrik Kehlet (Center for Surgical Pathophysiology in Copenhagen) and Prof. Douglas W. Wilmore from Boston University School of Medicine are considered pioneers of this new concept [4,5]. Although various specialties have embraced ERAS programs, they are currently most widely used concerning colonic and rectal surgery.

Looking back to the origins of "fast-track" surgery, we can state that the principles behind the implementation and development of ERAS programs are as follows:

(I) Recognizing available evidence that has the potential to improve patients' postoperative recovery;

(II) Incorporating this evidence into appropriate therapeutic protocols tailored to each type of surgery;

(III) Developing hospital systems to assess compliance with individual program components.

**Current Status of the ERAS Protocol in Emergency Colorectal Surgery**

ERAS is a multidisciplinary program designed to minimize the surgical stress response and promote recovery of organ function. Implementation of an ERAS program has also been associated with better short- and long-term outcomes in patients with resectable colorectal cancer, including improved disease-free and overall survival [2].

In the ERAS Society's recommended guidelines for perioperative care in elective settings, there are 20–21 ERAS elements for colorectal surgery. Most of the principles in the protocol have been applied in emergency colorectal surgery, with some modifications. Some preoperative ERAS elements—such as nutritional support, carbohydrate loading, and complete optimization of medical conditions—are impossible to achieve in the emergency setting. However, almost all of the ERAS principles used in elective colorectal surgery could be applicable in emergency situations and are presented in Table 1.

**Table 1.** Modified and adapted ERAS principles for emergency colorectal surgery

| **Pre-operative principles** | **Intraoperative principles** | **Postoperative principles** |
|---|---|---|
| Education and counseling (including probability of ostomy) | Anesthesia and epidural analgesia | Multimodal analgesia |
| Medical optimization | Goal-oriented volemic therapy | Early nasogastric tube removal |
| Blood glucose control | Prevention of hypothermia | Early resumption of oral feeding |
| | Prophylaxis for nausea and vomiting (PONV) | Early removal of catheters (peripheral and central urinary and venous) |
| | Preference for minimally invasive surgery | Respiratory physiotherapy |
| | Avoidance of intraperitoneal drainage tubes | Early active mobilization |

# I. A Comparative Analysis Between Enhanced Recovery After Surgery (ERAS) and Traditional Care in the Management of Obstructive Colorectal Cancer

The objective of this study was to compare the mortality and morbidity of patients undergoing colonic or rectal resection and treated according to either ERAS or conventional postoperative care principles. This evaluation aims to determine the clinical implications of enhanced perioperative management (ERAS).

## 1. Materials and Methods

### 1.1. Patient Identification

During the study period, 162 consecutive patients were admitted for colorectal cancer with clinically and radiologically proven bowel obstruction (confirmed by contrast-enhanced computed tomography of the abdomen and pelvis). A total of 24 patients underwent colonic stent insertion (12 for palliative care and 12 as a bridge to surgery), 30 patients had a shunt stoma performed in continuity, and 120 consecutive cases underwent emergency tumor resection.

We conducted a prospective, observational, longitudinal cohort study. We included all patients (n = 120) diagnosed with bowel obstruction due to colorectal cancer and treated between January 2018 and December 2021 at the University Emergency Hospital, Surgery Department IV, Bucharest, Romania.

Written informed consent was obtained from all patients. Patients were treated either according to traditional care routines (traditional group, n = 80) or according to a modified ERAS protocol adapted for patients with obstructive colorectal cancer (ERAS group, n = 40). Nutritional status was assessed using serum albumin levels in both groups. Nutritional supplements were administered postoperatively, parenterally and/or orally, to malnourished patients to relieve symptomatic obstruction (dynamic ileus).

Evidence of complete or near-complete colonic obstruction was confirmed by CT, with direct imaging signs including the invasiveness and localization of the tumor in the upper colon or rectum, and the presence of upstream colonic distension and fluid levels caused by the stenosing tumor.

### 1.2. Exclusion Criteria

Patients with clinically suspected peritonitis (sepsis with abdominal origin) and confirmed by imaging (pneumoperitoneum or intra-/retroperitoneal collections), those with recurrent obstructive tumors, and those who received neoadjuvant treatments were excluded. Patients with metastatic and/or unresectable tumors were also excluded.

### 1.3. ERAS Protocol

Some elements of the ERAS protocol—such as intraoperative epidural analgesia and avoidance of routine postoperative abdominal drainage and nasogastric tubes—were already standard practice at the beginning of the study and were therefore included in the traditional perioperative care for elective patients. A summary of the major differences between the ERAS

program and conventional care management in terms of perioperative protocols is shown in Table 2.

**Table 2**. Perioperative ERAS protocol and comparison with conventional care.

| **Perioperative protocol** | **Non-ERAS** | **ERAS** |
|---|---|---|
| Pre-operative patient education and counseling | General counseling and advice given exclusively by surgeons | Comprehensive guidance and education provided {through written booklets} by surgeons, nurses, and anesthesiologists |
| Pre-operative fasting | No oral intake on day of surgery | Oral administration should occur up to 2 hours prior to induction of anesthesia |
| Perioperative IV fluid management | No restriction of fluid intake | Goal-directed fluid management during surgery, followed by controlled iv fluid administration postoperatively |
| Intra-operative hypothermia | Sometimes | No. Intraop active warming. |
| Nasogastric tube | Discontinued on day 2-3 post-op. | Removed immediately after surgery |
| Postoperative analgesia | Postoperative pain relief frequently depends on intravenous administration of opioid medications | Pain management usually involves use of non-opioid medications |
| Postoperative fasting | No oral intake for three days after surgery or sometimes until bowel transit resumes | Consume water two hours after surgery and switch to oral nutritional supplements on postoperative day 1 |
| Intestinal motility stimulation | No | Sometimes |
| Postoperative active mobilization | Standard walking regimen, usually starting on postoperative day 2 | Engage in activities outside of bed on postoperative day 1 |
| Drainage tubes | Withdrawn within 3-7 days after surgery | Avoid use of these |

All clinical outcomes were prospectively recorded. Nutrition, food intake, fluid balance, and mobilization were recorded daily until discharge. The degree of mobilization was jointly documented by both the medical staff and the patients in a patient diary. Identical assessment criteria were used throughout the study period: the patient had to be fully mobilized, afebrile, able to tolerate normal or near-normal amounts of solid food and liquids, have restored bowel function, and have pain adequately controlled without opioids.

The following variables were considered as possibly influencing postoperative outcomes:

- **Duration of obstruction (days):** time without gastrointestinal transit at the time of admission.
- **Estimated blood loss (mL):** assessment of intraoperative blood loss.
- **Postoperative hematocrit (%):** correlates with the efficiency of maintaining blood homeostasis (volume vs. rheology).
- **Locoregional anesthesia (Yes/No):** includes thoracic, high thoracic, or lumbar epidural catheters (EP), subfascial blocks (B), and local anesthesia (LA).
- **Intra/postoperative IV fluids (mL):** total volume administered intraoperatively and daily for the first 10 postoperative days.
- **Time to first flatus (days):** time from surgery to resumption of gas transit, indicating return of gastrointestinal function.
- **Time to first defecation (days):** time from surgery to first bowel movement of non- watery consistency.
- **Postoperative complications (Yes/No):** complications diagnosed within 30 postoperative days, including wound, hemorrhagic, infectious, cardiovascular, respiratory, anastomotic (fistula), and prolonged postoperative ileus. These were discussed generically as no significant statistical difference was found between groups.
- **Type of surgery (Open/Laparoscopic):** either conventional open surgery (C) or minimally invasive laparoscopic surgery (L).
- **Number of surgeries:** total number of surgical interventions during hospitalization.
- **Readmissions (Yes/No):** return to hospital for surgical or conservative treatment of complications.
- **Number of drainage tubes placed:** at the time of surgery.
- **Postoperative drainage duration (days):** time until the last intra-abdominal drain was removed.
- **ICU admission (days):** as well as need for ICU readmission (Yes/No).
- **Preoperative SNG (nasogastric tube):** duration of preoperative tube placement (<24h, 24–48h, >48h).
- **Postoperative SNG (days):** duration of postoperative nasogastric tube placement, and need for repositioning (Yes/No).
- **Hospitalization-to-surgery interval (days):** time from admission to surgery.
- **Hospitalization-to-discharge interval (days):** total hospital stay.

- **Urinary catheter on admission (Yes/No):** used for monitoring diuresis during rebalancing.
- **Postoperative urinary catheter removal (days):** duration of catheter placement after surgery.
- **Use of opioids, NSAIDs, and lidocaine (Yes/No):** for analgesia.
- **Stoma (Yes/No):** whether a temporary colostomy or ileostomy was performed after resection.
- **NPO (nil per os) duration (days):** time without oral intake postoperatively.
- **Time to oral feeding (days):** from surgery until reintroduction of anything other than clear liquids.
- **Parenteral nutrition (days):** duration of parenteral or total parenteral nutrition.
- **Mobilization (days):** time from surgery to first ambulation.
- **Antibiotic therapy (days):** total perioperative duration.
- **Human albumin administration (days):** total perioperative administration time.
- **Transfusions (units):** units of blood products transfused.
- **Anticoagulants (Prophylactic/Therapeutic):** perioperative use.
- **Deaths (Yes/No):** two deaths occurred in the non-ERAS group.

Surgical staffing, technical aspects of surgery, antibiotic choice, and thromboprophylaxis protocols remained consistent during the study period.

To assess the homogeneity of the ERAS and non-ERAS groups and identify potential bias-inducing factors, the following demographic and nutritional variables were analyzed:

- **Age**
- **Sex**
- **Body Mass Index (BMI)**
- **ASA (American Society of Anesthesiologists) score:** a classification system used to assess preoperative health status and predict perioperative risk.
- **Tumor location (Right/Left):** anatomical segment (cecum, ascending, hepatic flexure, transverse, splenic flexure, descending, sigmoid, rectosigmoid junction).
- **Type of surgical resection:** right hemicolectomy (RH), left hemicolectomy (LH), segmental resection (SR), rectosigmoid resection (RSR).
- **TNM staging:** stages I–III.
- **Admission hemoglobin (g/dL)**
- **Preoperative serum albumin (g/dL)**

### 1.4. Statistical Analysis

The database was completed using information from clinical records, electronic medical records, informed consent documents, and home follow-up forms. Data were processed using SPSS software (version 15.0 for Windows). Continuous variables were expressed as means ± standard deviation or medians (range). Unpaired t-tests were used for normally distributed data; Mann–Whitney U tests were applied for non-parametric distributions. Categorical variables were compared using Pearson's chi-square, Spearman correlation, or Fisher's exact test, as appropriate. A p-value $< 0.05$ was considered statistically significant. Unless otherwise specified, comparisons were made between the non-ERAS and ERAS groups.

## 2. Results

Of the 120 patients who underwent tumor resection during the same hospitalization, 40 (33.3%) were treated under the ERAS protocol. For comparison, 80 patients received conventional postoperative care and were included in the non-ERAS group. The two groups were comparable in terms of age, sex, BMI, ASA score, preoperative hemoglobin, and serum albumin levels. Characteristics and operative details are summarized in Table 3.

The similar ASA scores between groups suggest comparable baseline health status, enhancing the reliability of outcome comparisons. This homogeneity allows attribution of differences in outcomes more confidently to the ERAS protocol.

Patients were stratified by type of surgery: colonic resection (with or without anastomosis) or colorectal resection (for tumors under the peritoneal reflection, including the upper rectum and rectosigmoid junction). Data collected included patient demographics, operative details (tumor location, procedure type, operative time, estimated blood loss), pathologic staging, and postoperative outcomes. These included complications (infectious, respiratory, hemorrhagic, fistulae, eviscerations), time to first flatus and bowel movement, time to diet resumption, length of stay, readmission, and mortality. All patients were followed up 30 days postoperatively. Operative and postoperative details are shown in Table 4.

Patients in the ERAS group had significantly fewer stomas compared to patients in the non-ERAS group ($p = 0.01$). This suggests that the ERAS protocol may effectively reduce the need for stoma. We sought to determine the reason for the lower incidence of ostomies in the ERAS group and tested whether it correlated with the delay of surgery and the type of surgery performed (open vs. laparoscopic), respectively. The result is statistically significant and supports that surgery delayed by at least 24 hours "protects"

against the need for an ostomy (OR < 1). In other words, early surgery is associated with a "risk" of stoma approximately four times higher (1/0.2519).

**Table 3.** Demographic and anatomic-clinical characteristics of the patients included.

| **Patient data** | **Non-ERAS** | **ERAS** | **p** |
|---|---|---|---|
| **Number** | 80 | 40 | |
| **Age** | 68,3 ± 8,17 | 66,4 ± 9,88 | 0,4372 |
| **Sex** | | | |
| Male | 44 (55%) | 24 (60%) | 0,3628 |
| Female | 36 (45%) | 16 (40%) | |
| **BMI** (body mass index) | 28,83 ± 4,6 | 27,05 ± 4,93 | 0,0478 |
| **ASA score** | | | |
| II | 36 (45%) | 18 (45%) | 0,9557 |
| III | 34 (42,5%) | 18 (45%) | |
| IV | 10 (12,5%) | 4 (10%) | |
| **Hb** (on admission) | 11,575 ± 2,04 | 10,93 ± 2,01 | 0,2394 |
| **Albumin (on admission)** | 3,57 ± 0,47 | 3,51 ± 0,59 | 0,7594 |
| **Tumor localization** | | | |
| Right/Left colon | 29 (36.25%)/51 (63.75%) | 14 (35%)/26 (65%) | 0.2343 |
| Ascending colon | 13 (16.25%) | 7 (17.5%) | 0,9415 |
| Hepatic flexure | 8 (10%) | 4 (10%) | |
| Transverse colon | 8 (10%) | 3 (7.5%) | |
| Splenic flexure | 5 (6.25%) | 2 (5%) | |
| Descending colon | 10 (12.5%) | 6 (15%) | |
| Sigmoid colon | 12 (15%) | 5 (12.5%) | |
| Recto-sigmoid junction | 11 (13.75%) | 7 (17.5%) | |
| Upper rectum | 13 (16.25%) | 6 (15%) | |

**Table 4.** Intraoperative and postoperative variables.

| **Type of variables** | **Non-ERAS (n=80)** | **ERAS (n=40)** | **p** |
|---|---|---|---|
| Duration of obstruction (days) | 5.95 | 5.75 | 0.8742 |
| Duration of surgery (min) | 154.12 ± 38.7 | 175.5 ± 52.11 | 0.1260 |
| Intraoperative bleeding (mL) | 327.5 ± 221.8 | 305 ± 216.97 | 0.5542 |
| Locoregional anesthesia | 10 (12.5%) | 32 (80%) | 0.0000 |
| Intraoperative fluids iv (L) | 5.08 ± 1.35 | 2.67 ± 0.97 | 0.0000 |
| Postoperative fluids iv (L) | 20.8 ± 9.01 | 5.15 ± 2.42 | 0.0000 |
| Stoma (no.) | 54 (79.41%) | 7 (20.59%) | 0.0103 |
| Drainage days | 5.45 ± 3.79 | 1.25 ± 1.61 | 0.0000 |
| Gas transit resumption (days) | 2.45 ± 2.57 | 2.5 ± 1.63 | 0.4791 |
| Fecal transit resumption (days) | 3.90 ± 3.74 | 3.7 ± 2.31 | 0.7877 |
| Duration of hospitalization (days) | 10.75 ± 5.3 | 6.85 ± 2.39 | 0.0002 |
| Postoperative complications | 48 (60%) | 20 (50%) | 0.2386 |

The statistical analysis shows that delaying surgery increases the rate of minimally invasive surgery in the ERAS group, while the type of surgery (open or laparoscopic) does not statistically significantly correlate with the need for a stoma (p = 0.08688), nor with the incidence of complications.

Patients in the ERAS group had a significantly shorter hospitalization. The mean

length of stay in the ERAS group was 6.8 days (range: 4–12), compared to the non-ERAS group, where it was 10.7 days (range: 6–32), with a t-test $p = 0.0002$, despite a significantly longer interval between admission and surgery in the ERAS group. There was also a stronger and statistically significant correlation between the admission-to-operation interval and the duration of postoperative hospitalization in the ERAS group ($r = 0.658$, $p = 0.002$), compared to the non-ERAS group ($r = 0.339$, $p = 0.032$).

There were no significant differences in complication rates or readmission rates between the two groups. However, the ERAS group had slightly fewer complications compared to the non-ERAS group (50% vs. 60%), though this difference did not reach statistical significance ($p = 0.238$). In the ERAS group, however, the risk of postoperative complications was higher in patients undergoing open surgery compared to those undergoing laparoscopic surgery ($p = 0.015$).

This suggests that implementation of the ERAS protocol does not increase the risk of postoperative complications, providing reassurance that these improved recovery strategies are safe for patients. Although the ERAS protocol is designed to improve recovery time and reduce hospitalization, it does not negatively impact overall complication rates. This balance of improved efficiency while maintaining safety highlights the potential benefits of incorporating ERAS protocols into standard surgical practice.

## 3. Conclusions

Patients in the ERAS group had fewer stomas and received less postoperative fluid compared to those in the non-ERAS group. In addition, patients who followed the ERAS protocol had faster drain tube removal compared to those who did not follow the protocol. However, patients in the ERAS group who underwent open surgery had a significantly higher risk of postoperative complications compared to those who underwent laparoscopic surgery. The complication and readmission rates did not differ significantly between the ERAS and non-ERAS groups. However, the ERAS group experienced slightly fewer complications. Additionally, patients in the ERAS group had shorter hospital stays compared to those in the non-ERAS group.

ERAS guidelines are already widely used in elective surgical practice. However, there has been some caution in applying ERAS in emergency cases due to a perceived higher risk of complications. Our study demonstrated no significant differences in the risk of complications between emergency cases managed with ERAS and those managed with traditional methods. This finding supports the successful implementation of ERAS in emergency situations, indicating that it can be applied without imposing additional risk to

patients.

Findings from this study indicate that the ERAS program is superior to conventional postoperative care for patients undergoing surgery for occlusive colorectal cancer. Combining laparoscopic surgery with ERAS protocols appears to offer additional advantages beyond those offered by laparoscopic surgery alone, and ERAS should likely be adopted regardless of surgical technique. This observation confirms the concept of multimodality as the foundation of ERAS success, demonstrating that the combination of different elements in ERAS protocols is responsible for improved recovery—rather than any single element alone.

The limitation of this study is the relatively small sample size, which may affect the generalizability and statistical power of the results. This is partly due to the fact that the ERAS method has not yet been widely adopted as a standard protocol, with few surgical teams having experience in its implementation. However, the strengths of the study include the consideration of more than 50 variables, from which the most relevant and statistically significant were selected and discussed for their clinical importance.

# II. Progression and Risk Scores in Patients Hospitalized for Occlusive Colorectal Cancer

## 1. Introduction

Colorectal cancer (CRC) is the third most common cancer globally, with a median 5-year survival rate of 60% [7]. CRC surgery is widely performed worldwide to address both benign and malignant conditions. Given the nature of CRC surgery, patients generally remain hospitalized until they can adequately meet their nutritional needs and regain the ability to walk independently [8].

In any hospital, the relationship between complications and length of stay (LOS) is dynamic and interconnected. When complications occur, they often lead to prolonged hospitalization as they require additional time for management, treatment, and recovery. Conversely, prolonged hospitalization itself can increase the risk of complications. This bidirectional relationship creates a challenging cycle: complications prolong the hospital stay, and longer stays raise the risk of further complications [9,10].

Accurate LOS predictions allow healthcare facilities to more efficiently allocate resources such as beds, medical staff, and equipment. Financial management and cost control are also key areas influenced by LOS forecasts. Moreover, accurate LOS prediction

helps improve patient care and enhance the overall hospital experience. Colorectal resections typically result in an average hospitalization of 6 to 11 days and have a complication rate between 15% and 20% [11].

Over 60 variables were analyzed, including age, sex, BMI, interval between admission and surgery, total days of hospitalization, hemoglobin at admission, days without preoperative transit, type of analgesia, type of anesthesia, tumor location, and complications. Of these, some were found to be positively or negatively correlated with the occurrence of complications. Six parameters, which represent risk factors for complications, were used to calculate the complication score: hemoglobin (Hb), preoperative serum albumin, tumor location, presence of an epidural catheter (EC), opioid use, and NPO status (nil per os).

## 2. Material and Methods

### 2.1 Patient Identification

This retrospective study focused on a cohort of patients treated between January 2022 and December 2023. Data were collected using medical records. Patients with peritonitis secondary to perforated colorectal tumors, recurrent obstructive tumors, or those undergoing neoadjuvant therapy were excluded from the study. Additionally, patients with unresectable tumors or those diagnosed with metastatic disease were not included in the analysis. From an initial cohort of 167 patients, 47 were excluded based on predefined criteria, leaving a final cohort of 120 patients for analysis.

### 2.2 Statistical Analysis

Statistical analysis was performed using IBM SPSS version 25 (IBM Corp., Armonk, NY, USA), Epi Info Version 7.2 (CDC, Atlanta, GA, USA), and Microsoft Excel from the Microsoft 365 suite (Microsoft Corp., Redmond, WA, USA). The risk score for complications was developed using receiver operating characteristic (ROC) curve analysis and odds ratios. ROC curve analysis was used to identify the optimal cutoff points for the numeric variables in our group. Based on these cutoffs, variables were dichotomized. Odds ratios were then used to quantify the association between each dichotomized variable and outcome. A statistical significance threshold of $p < 0.05$ was considered for all analyses.

## 3. Results

### 3.1 Risk Score for Complications

The risk score for complications was calculated based on six key parameters: hemoglobin (Hb) at admission, preoperative serum albumin, tumor location, use of an epidural catheter (EC), opioid use, and duration of NPO status. Tumor location identified whether the tumor was in the right or left colon (including the upper rectum). The EC

parameter recorded whether an epidural catheter was used (Yes/No). The opioid use parameter indicated whether opioids were administered (Yes/No). NPO status referred to the duration the patient was not allowed oral intake postoperatively.

Figure 1 illustrates the relationship between Hb levels, preoperative serum albumin, and NPO duration in relation to the incidence of postoperative complication.

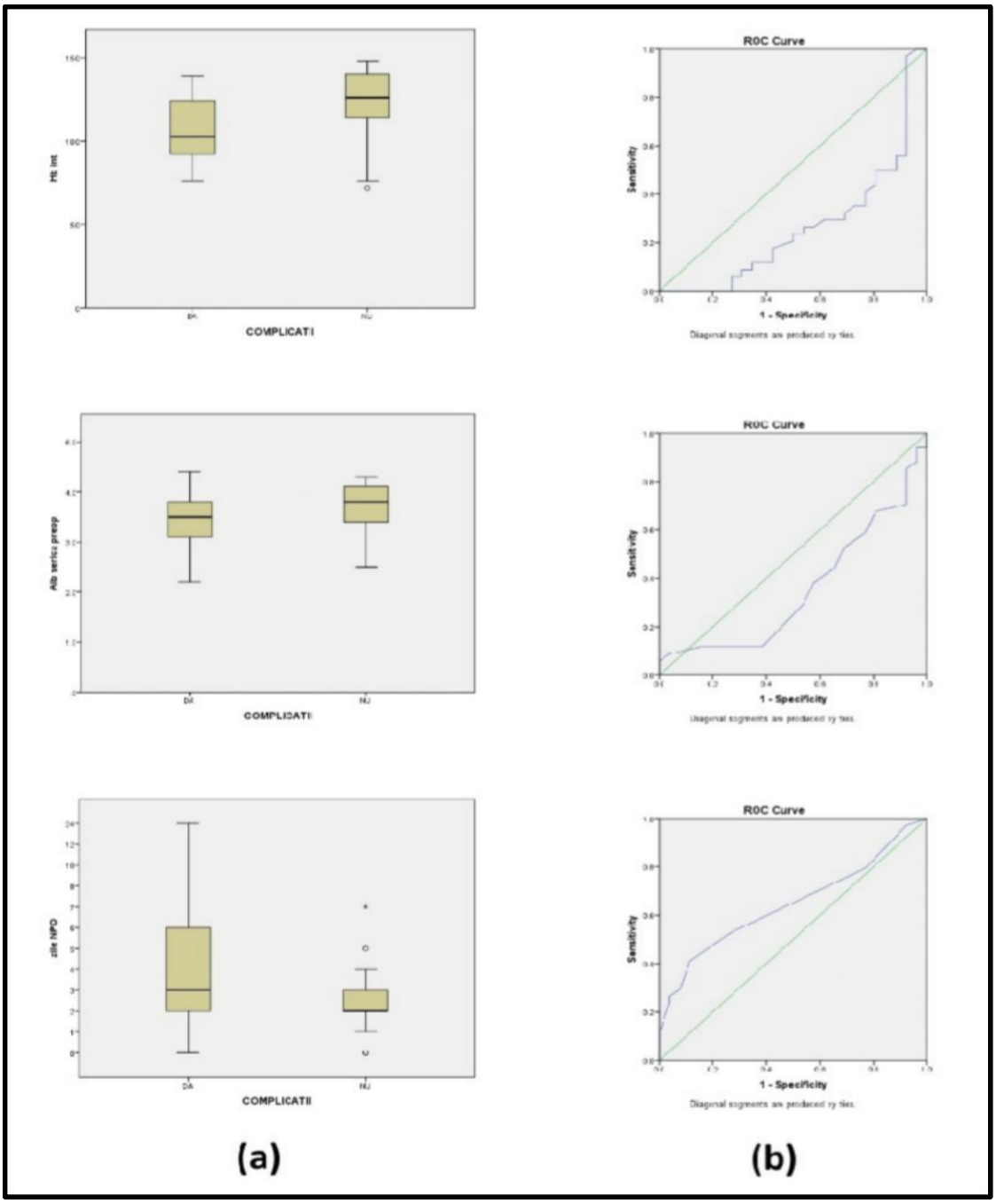



**Figure 1**: Relationship between levels of Hb (hemoglobin), preoperative serum albumin, duration of NPO (null per os) and incidence of postoperative complications.(a) Boxplot comparing the distribution of patient groups based on the presence or absence of postoperative complications (mean ± SD); (b) ROC curve assessing the predictive accuracy of variables (Hb, preoperative serum albumin, NPO) in identifying patients at higher risk of postoperative complications, with the area under the curve (AUC) reflecting their overall discriminative power

.

Analyzing the risk of complications associated with tumor location, we found that right colon location is a risk factor, as the complication rate for this location was statistically significantly higher (73.91% vs. 45.95%, p = 0.0190). This could be explained by a higher rate of anastomosis in right colon resections and a higher rate of ostomies in left colon resections.

With regard to the use of epidural catheters for perioperative pain control, their use was found to be associated with a statistically significant lower risk of complications, thus representing a protective factor (p = 0.05). This is closely correlated with a lower rate of opioid analgesia, which was identified as a risk factor for the development of complications (p = 0.0213).

For the numerical variables associated with an increased risk of complications, a cut-off value was established using ROC curves, and we then tested whether these variables could be useful in calculating a complication risk score. The odds ratios (ORs) and p-values obtained for each variable (Hb and serum albumin on admission, as well as duration of NPO) were recorded.

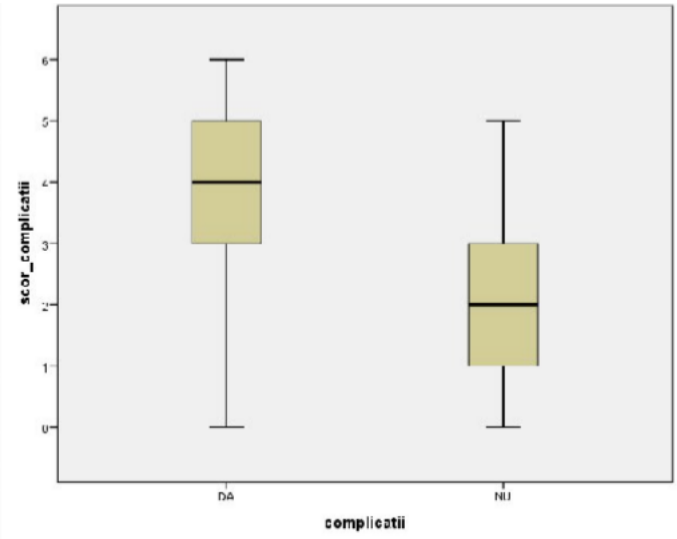



**Figure 2**: Graphical representation of the relationship between postoperative complications and complication scores, indicating that higher complication scores are related to an increased incidence of complications.

For the complication score, we assigned 1 point for each factor found to be significantly associated with the development of postoperative complications: Hb < 11.05 g/dL on admission; preoperative serum albumin < 3.55 g/dL; tumor location in the right colon; no use of epidural catheter (EC); opioid use: yes; duration of NPO > 2.5 days. Thus,

patients who accumulated at least three of the six possible points had a complication rate 6.17 times higher than those with fewer points ($p = 0.0008$), indicating a very strong correlation between the score and the likelihood of postoperative complications. The high level of statistical significance supports the reliability of this score as a predictor of complications and highlights its potential utility in clinical practice for identifying high-risk patients (Figure 2).

### 3.2 Risk score for prolonged hospitalization

For this score, we evaluated the statistical significance of both numerical and non-numerical variables on the duration of hospitalization: age, sex, admission-to-operation interval, days without preoperative transit, hemoglobin at admission, serum albumin, BMI, tumor location (right colon/left colon), intraoperatively infused fluids, IV fluids in the first 3 days, opioid use, NSAID use, and NPO days. In addition to these, we analyzed the correlation of hospitalization duration with new variables such as: gastric and urinary catheterization on admission, local anesthesia and analgesia, duration of surgery, prophylactic/therapeuticanticoagulation, number of drainage tubes, ASA score, postoperative hematocrit value, and intraoperative blood loss volume.

Statistically significant differences in duration of hospitalization, categorized as 0–7 days versus 8+ days, were observed for several key factors. These included hemoglobin levels at admission, tumor location (right vs. left colon), volume of intraoperative fluid administration, use or absence of regional anesthesia and analgesia (RAA), number of drainage tubes placed, and postoperative hematocrit levels. Each variable demonstrated a significant impact on the length of hospitalization, suggesting their importance in predicting and managing patient recovery after surgery. Intraoperative fluid volume refers to the total amount of fluids (including intravenous fluids, blood products, and other solutions) administered during the operation. The use of the RAA parameter indicates whether regional anesthesia and analgesia techniques were employed during the procedure, recorded as “yes” if used and “no” if not. The number of drainage tubes refers to the total number of tubes placed in the patient after surgery. Postoperative hematocrit (Ht) levels represent the percentage of red blood cells in the patient’s blood immediately after the procedure.

Analyzing the risk of prolonged hospitalization (>7 days) associated with tumor location, we found that right colon location is a risk factor, as the duration of hospitalization for this group was statistically significantly higher (73.91% vs. 45.95%, $p = 0.0190$). Similarly, the use of RAA (even in combination with general anesthesia) for perioperative pain control was associated with a statistically significantly lower risk of

prolonged hospitalization, making it a protective factor (p = 0.05). Figure 3 illustrates the relationship between admission hemoglobin levels, intraoperative fluid volume, number of drainage tubes, postoperative hematocrit levels, and length of hospitalization, classified as either 0–7 days or 8+ days.

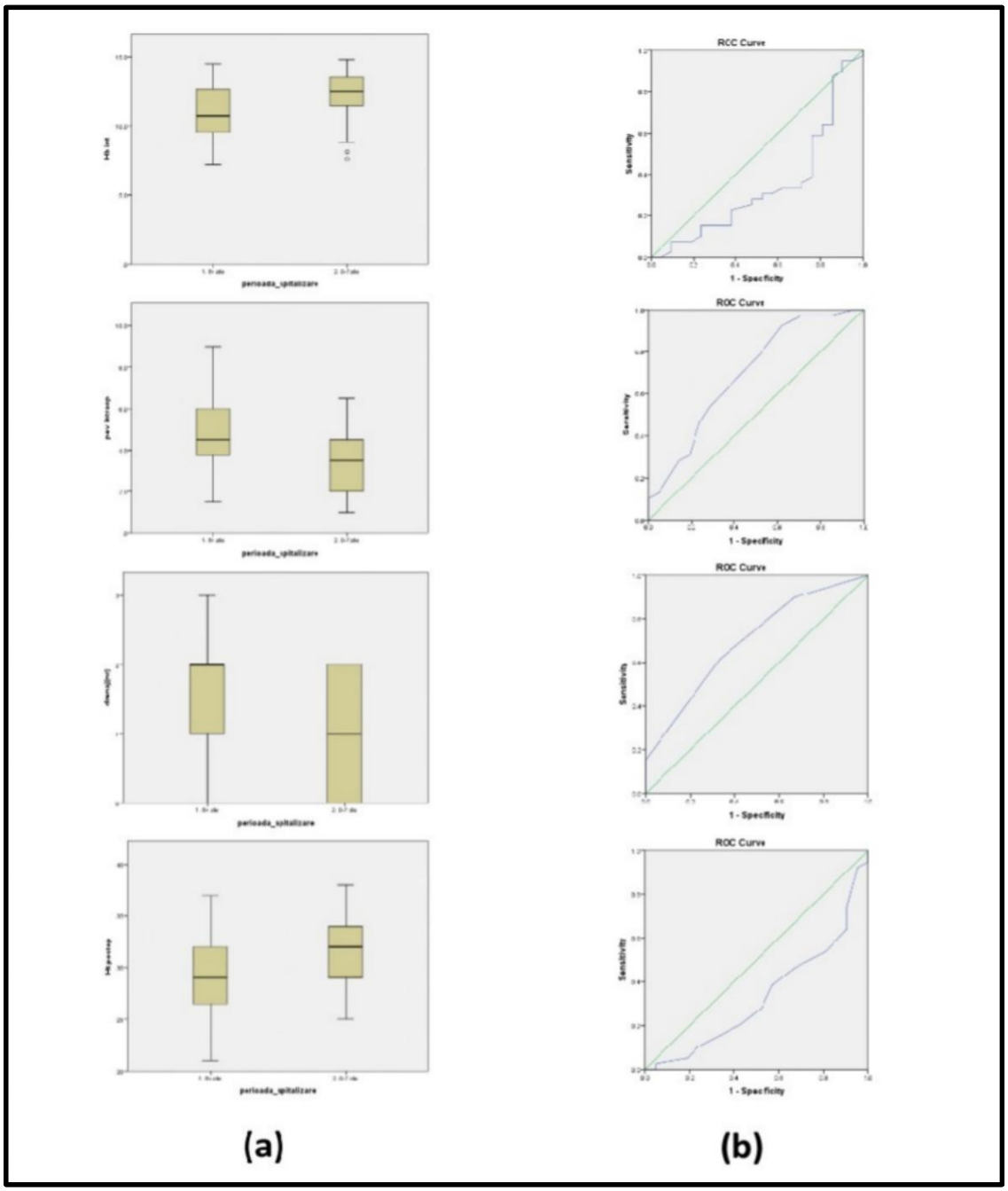
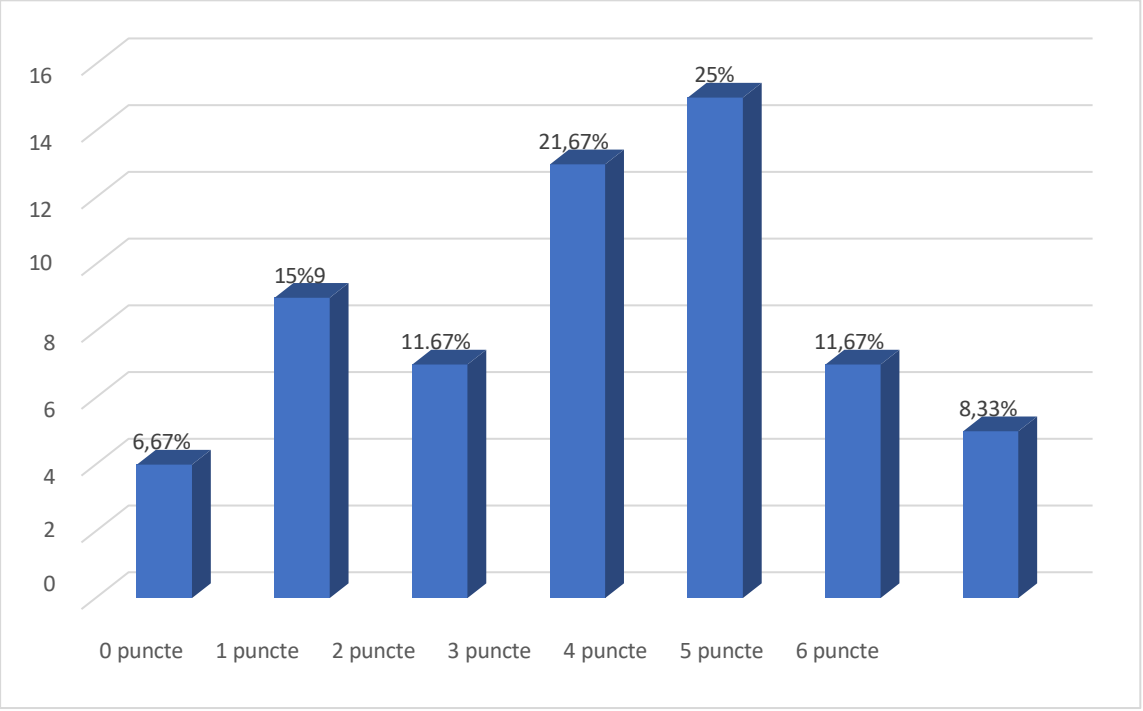



**Figure 3**: Relationship between Hb (hemoglobin) levels on admission, intraoperatively perfused fluid intake, number of drainage tubes, postoperative hematocrit level, and length of hospitalization.
(a) Boxplot comparing the distribution of patient groups based on length of hospitalization, classified as either 0- 7 days or 8+ days (mean ± SD); (b) ROC curve assessing the predictive accuracy of variables (Hb levels on admission, intraoperative fluid intake, number of drainage tubes, postoperative Ht level) in identifying patients at higher risk of postoperative complications, with the area under the curve (AUC) reflecting their overall discriminative power.

A strong association was found between tumor location (right vs. left colon) and length of stay, with a p-value of 0.0492. The presence or absence of RAA also showed a highly statistically significant correlation with hospitalization duration (p = 0.0236). For the risk score of prolonged hospitalization—defined as 0–7 days versus 8+ days—we assigned 1 point for each of the following factors found to be significantly associated with an increased risk of prolonged stay:

- Hemoglobin at admission <11.05 g/dL
- Tumor location: right colon
- Intraoperative fluid volume >3.75 liters
- Absence of RAA
- Number of drainage tubes ≥2
- Postoperative hematocrit <29.5%

Figure 4 illustrates the relationship between length of hospitalization and the score for prolonged hospitalization risk. The analysis shows that patients with three or more of these six risk factors had a significantly higher likelihood of prolonged hospitalization, defined as a stay longer than eight days. Specifically, these patients were 5.17 times more likely to experience a prolonged hospitalization compared to those with fewer than three risk factors. This correlation was both strong and statistically significant (p = 0.003).



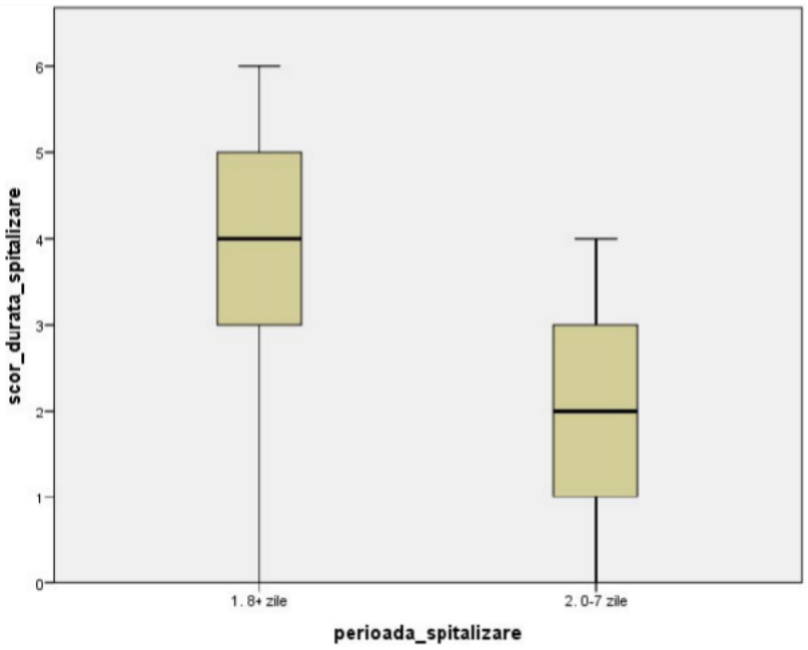



**Figure 4:** Graph illustrating the relationship between length of hospitalization and DS score showing that higher scores are associated with longer hospitalization.

## 4. Conclusions

The development of the complication score, based on six key risk factors, demonstrates a robust predictive ability to identify patients at higher risk of postoperative complications. The significant correlation observed—where patients with three or more points experienced a 6.17-fold increase in complication rates—highlights the importance of monitoring these parameters. With a p-value of 0.0008, the results affirm the reliability of the score as a tool to guide clinical decision-making and resource allocation.

The findings of this study emphasize the significant impact of different factors on the duration of stay (DS) after resection of emergency colorectal cancers. The identification of key variables (hemoglobin level, tumor location, intraoperative fluid intake, use of locoregional anesthesia, number of drainage tubes, and postoperative hematocrit levels) highlights their critical role in predicting the length of hospital stay. Patients with three or more risk factors face a significantly increased likelihood of prolonged DS, being 5.17 times more at risk of hospitalizations exceeding eight days. The strong statistical significance of these results, with a p-value of 0.003, further reinforces the usefulness of the score in practice.

This scoring system can serve as an essential tool for healthcare providers to identify at-risk patients, optimize resource allocation, and ultimately improve patient recovery and outcomes. Furthermore, integrating complication and DS scores into routine preoperative

assessments can facilitate a more personalized care plan, allowing healthcare providers to identify patients who may benefit from more extensive monitoring and additional support during recovery. As we move toward more evidence-based care practices, these systems provide valuable information that can improve the quality of care for patients with occlusive colorectal cancer. Continued research and validation of these scores in diverse patient populations will be essential to refine their applicability and effectiveness in different clinical settings.

The ability to accurately predict postoperative complications is essential for optimizing patient care, improving outcomes, enhancing patient safety, and efficiently managing medical resources. It is a key component of modern surgical practice that drives both clinical and operative success. The aim of this study was to develop a scoring system designed to provide healthcare professionals with a predictive tool that assesses the likelihood of postoperative complications and the potential for prolonged hospitalization in patients undergoing colorectal cancer surgery.

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**List of Publications from the PhD Thesis Topic**

1. Mihailescu AA, Gradinaru S, Kraft A, Blendea CD, Capitanu BS, Neagu SI Enhanced rehabilitation after surgery: principles in the treatment of emergency complicated colorectal cancers - a narrative review. Journal of Medicine and Life, 2025, 18(3),179-187,ImpactFactor-1.61/2023,DOI:10.25122/jml-2025-0049 https://medandlife.org/all-issues/2025/issue-3-2025/review-issue-3-2025/enhanced-rehabilitation-after-surgery-principles-in-the-treatment-of-emergency-complicated-colorectal-cancers-a-narrative-review/

2. Mihailescu AA, Onisai M, Alexandru A, Teodorescu M, Alius C, Blendea CD, Neagu SI, Serban D, Gradinaru S. A comparative analysis between enhanced recovery after surgery and traditional care in the management of obstructive colorectal cancer Medicina, 2024, 60(8), 1319, Impact Factor - 2.4/2023, Q2, Chapter II.1, pages 66-99, DOI:10.3390/medicina60081319 https://pmc.ncbi.nlm.nih.gov/articles/PMC11356555/

3. Mihailescu AA, Dragosloveanu S, Onisai M, Teodorescu M, Alexandru A, Alius C, Blendea CD, Neagu SI, Serban D, Gradinaru S. Pursuing better outcomes in obstructive colorectal cancer surgery: a new predictive scoring system for immediate complications and optimization of hospital stay. Cureus, 2024, 16(12), Impact Factor - 1.2/2023, Q3, Chapter II.2, pages 99-126, DOI: 10.7759/cureus.76237 https://www.cureus.com/articles/312985-pursuing-better-outcomes-in-obstructive-colorectal-cancer-surgery-a-new-predictive-scoring-system-for-immediate-complications-and-optimization-of-hospital-stay#!/