Review Article

# Anesthesia and perioperative management of colorectal surgical patients – specific issues (part 2)

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## Abstract

Colorectal surgery carries significant morbidity and mortality, which is associated with an enormous use of healthcare resources. Patients with pre-existing morbidities, and those undergoing emergency colorectal surgery due to complications such as perforation, obstruction, or ischemia / infarction are at an increased risk for adverse outcomes. Fluid therapy in emergency colorectal surgical patients can be challenging as hypovolemic and septic shock may coexist. Abdominal sepsis is a serious complication and may be diagnosed during pre-, intra-, or postoperative periods. Early suspicion and recognition of medical and / or surgical complications are essential. The critical care management of complicated colorectal surgical patients require collaborative and multidisciplinary efforts.

**Key words**: Anesthesia, Colorectal surgery, complications, critical care, emergency, fluid therapy, intestinal

## Introduction

Anesthesiologists play a crucial role in the management of complicated and critically ill colorectal (CR) surgical patients. In part 1, we have reviewed some fundamental clinical aspects such as stress response, preoperative care and pain management for CR surgical patients. Specific and important issues relating to colorectal surgery, such as emergency surgery, fluid therapy, blood transfusion, and postoperative complications are discussed in this review. The management of critically ill colorectal surgical patients requires meticulous fluid and electrolyte therapy, maintenance or improvement of systemic and colon oxygen delivery, and multidisciplinary team involvement [Figure 1].

## Emergency colorectal surgery

Emergency surgery is often required due to complications such as perforation, obstruction, or bleeding, depending on the primary pathology. For colon cancer, the most common emergency is obstruction followed by perforation. For diverticular disease, perforation is the most common indication for emergency surgery. Colonic perforation leading to secondary peritonitis occurs most commonly in the sigmoid colon, due to diverticular disease or cancer.[1] In patients with inflammatory bowel condition, urgent surgery may be needed if there is no improvement with medical therapy. Emergency surgery may also be required following a complication of elective surgery, for example, an anastomotic dehiscence or intra-abdominal abscess.

### *Severe peritonitis – A clinical challenge*

Many CR surgical patients are septic when a decision for surgery is made. Sepsis may be the first sign of an underlying problem, or the sole indication for surgery. In extreme cases, hypovolemic or septic shock leading to organ dysfunction or failure may be present. In severe cases of peritonitis (e.g., purulent or fecal), hemodynamic instability should be anticipated and measures of early resuscitation are vital. Early input from experienced clinicians, nursing in high dependency or critical care environment, advanced hemodynamic monitoring and management (e.g., fluid resuscitation and use of vasopressors, inotropes) are necessary for optimal outcome. In addition, pre-existing medical diseases, associated fluid, electrolyte and metabolic disturbances, and systemic pathophysiological consequences can be life-threatening. Early and continued resuscitation is vital. Patients should be

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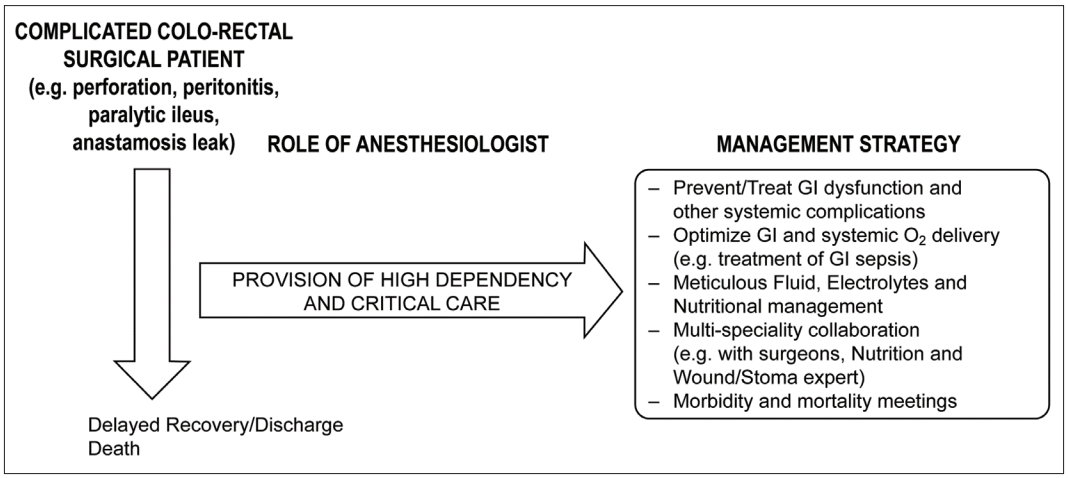


**Figure 1:** Management of complicated colorectal surgical patients. GI -gastrointestinal

managed as per evidence-based recommendations for sepsis.[2] A wide range of bacteria may cause colon-derived intra-abdominal infections, but facultative and obligate anaerobic organisms are the most common. The choice of antibiotic depends on risk factors for specific microorganisms, resistance patterns, and the patient's clinical condition.[3] Twenty-five percent of the patients undergoing emergency colorectal cancer surgery have postoperative medical complications leading to significant mortality.[4] Multi-organ dysfunction is the most common mode of death after emergency colorectal surgery.

### *Anesthetic management*

There is no specific choice for anesthetic agents or technique for emergency CR surgery. However, organ supportive measures should be continued during the intraoperative period. Advanced hemodynamic monitoring is indicated for fluid resuscitation and use of vasopressors / inotropes therapy is most likely. Little is known about the pharmacokinetics and regional hemodynamics of intravenous and inhalational anesthetic agents in the presence of abdominal sepsis. Some experimental studies have shown reduction of minimal alveolar concentration of inhalational anesthetic agents in the presence of sepsis. Interactions of vasopressors / inotropes and anesthetic agents, and their effects on colon microcirculation and oxygenation are not well studied. Under experimental conditions, sevoflurane and propofol have been shown to have differing modulatory effects on vasopressor actions on gastrointestinal oxygenation.[5]

The role of epidural anesthesia and analgesia in septic colorectal surgical patients is limited and its use in intensive care units is highly variable.[6] Consent issues, coagulopathy risks, cardiovascular instability, and an increased risk of infectious complications restrict its use in the presence of severe peritonitis.[6] In the presence of sepsis, effects of epidural on intestinal and systemic macro and microcirculation are not known in humans. In experimental normotensive endotoxemia, use of the epidural worsened intestinal microvascular mucosal perfusion, by impeding sepsis-induced redistribution of blood flow from the muscularis to the mucosa.[7] In contrast, Daudel *et al.*[8] reported improved intestinal mucosal capillary recruitment, possibly due to epidural-related sympathetic blockade in the presence of sepsis. Conflicting results regarding effects on intestinal circulation are due to different septic models and studies on different animals at different stages of sepsis.[9] Effective analgesia with epidural may facilitate weaning from mechanical ventilation and physiotherapy. However, these and other benefits such as improvement of gastrointestinal motility are not proven by scientific studies. Whatever may be the anesthetic or analgesic agent or technique used, the strategies should be to optimize systemic hemodynamics and prevent deterioration of end-organ function. Communication with team members, perioperative management by experienced staff, planning for postoperative care, and in some cases end-of-life care are important issues to consider.[10]

### *Serious risk factor for poor outcome*

In a recent study of 30-day postoperative mortality after CR cancer surgery for the period from 1998 – 2006 in the UK, 14.9% (95% CI 14.2 to 15.7%) of the patients operated as an emergency died, compared to only 5.8% (95% CI 5.4 to 6.2%) of those operated upon electively.[11] Emergency surgery itself is an independent risk factor for short-term (30 days) and long-term (one year and five years) morbidity and mortality, for colorectal surgical patients.[12-14] It is a determinant factor for five-year overall survival (57.5% after elective and 39.1% after emergency curative surgery) and cancer-specific survival.[12] In a large series by Sjo *et al.*,[13] 25% of the patients with colon cancer required emergency surgery. It was associated with an increased complication rate (38 vs. 24%) and mortality (10 vs. 3.5%), compared to elective surgery. Fiaz *et al.*[14] analyzed 102,236 non-elective surgery cases over 11 years in the UK. They found the

30-day in-hospital postoperative mortality rates in patients with colorectal cancer and diverticular disease to be 13.3 and 15.4%, respectively. In a recent retrospective study comprising 25710 non-emergency and 5083 emergency colorectal resections by Ingraham *et al.*, the risk for incurring at least one postoperative complication was 24.0% in non-emergency and 48.2% in emergency patients,while mortality was 1.9% in non-emergency and 15.4% in emergency patients.[15]

There is an institutional variation in the quality of care for these groups of patients.[16] To improve the quality of care for emergency CR surgery, institutions should identify and focus on local factors when planning the delivery of care. Post emergency surgery outcomes also depend on the postoperative care environment within a hospital. In an observational study by Clarke *et al.*,[17] in which 19.4% of patients died, the standardized mortality ratio (SMR) was higher for patients following a Post-Anesthesia Care Unit (PACU) pathway, as opposed to patients treated in critical care areas, highlighting the importance of optimized postoperative care in emergency bowel surgery.

Various risk scoring systems have been suggested to predict the mortality and morbidity.[18] In patients with secondary peritonitis, a combination of the APACHE II and the Mannheim peritonitis index provides the best prediction of outcome.[19]

## Fluid therapy

During the perioperative period, fluid therapy and gastrointestinal function may complement or complicate each other. If fluid therapy is not optimal it may lead to hypovolemia or hypervolemia [Figure 2.]. This in turn may cause a delayed recovery of gastrointestinal function and prevent early oral intake. If gastrointestinal dysfunction (e.g. PONV or paralytic ileus) develops during the perioperative period, it may lead to fluid and electrolyte loss (concealed or revealed) and metabolic problems.

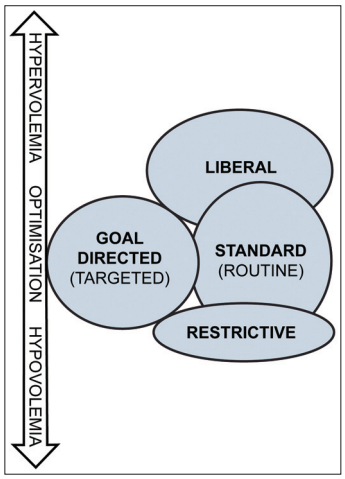


**Figure 2:** Types of fluid therapy

### *Types of fluid therapy*

Various types of fluid therapy [Figure 2] have been described and studied for CR surgical patients,[20] such as 'standard' (routine), 'liberal' (high volume), 'restrictive' (low volume) or 'goal directed' (targeted). Liberal use of fluid during the perioperative period is often based on the concept of 'third space' loss, fluid loss due to mechanical bowel preparation, and replacement of pre-existing deficits (e.g., physiological or pathological). Irrational and unmonitored use of 'fluid boluses' to manage hypotension (e.g., epidural-related) or low urine output may lead to an excess positive fluid balance. With restrictive fluid therapy, an earlier oral intake, gastrointestinal function recovery, and better pulmonary function are reported. [20,21] However, restrictive fluid therapy does not reduce the length of hospital stay either following conventional or fast track CR surgery. Vasopressors are more often required in a restrictive group.[22] A systematic evaluation by Bundgaard–Nilsen *et al.* found a lack of precise definitions and outcome endpoints among studies of liberal or restrictive regimens.[23] Restrictive fluid therapy and the use of vasopressors may raise concerns about systemic hypotension and reduced colon blood flow, respectively. However, in an experimental abdominal surgery model, the treatment of perioperative hypotension with norepinephrine during restricted fluid therapy did not impair the small and large intestine microcirculatory blood flow and oxygenation.[24]

To achieve an optimal fluid balance, goal directed (GD) fluid administration has been recommended.[25] Stroke volume measurement using an esophageal Doppler probe has been used in various studies. Earlier studies had shown that GD fluid therapy accelerates gastrointestinal function recovery and is associated with a shorter hospital stay. However, a recent double-blinded controlled trial failed to show any benefits of stroke volume–guided GD over standard fluid management, and even resulted in an increased length of stay in aerobically fit patients.[26] Central venous oxygen (ScvO2) –targeted fluid therapy also did not result in a better clinical outcome when compared to standard fluid therapy.[27] Targeted fluid therapy may not show benefits with laparoscopic surgery and with a fast track recovery program.[28] Large, multicenter randomized controlled trials are necessary before GD fluid therapy can be established as a gold standard approach. Also, GD therapy has not been compared with other fluid regimens, for example, restrictive or liberal and GD fluid therapy using stroke volume measurement has not been compared with other endpoints to judge the fluid responsiveness, for example, pulse pressure variation, systolic pressure variation, stroke volume variation or mixed venous oxygen saturation.

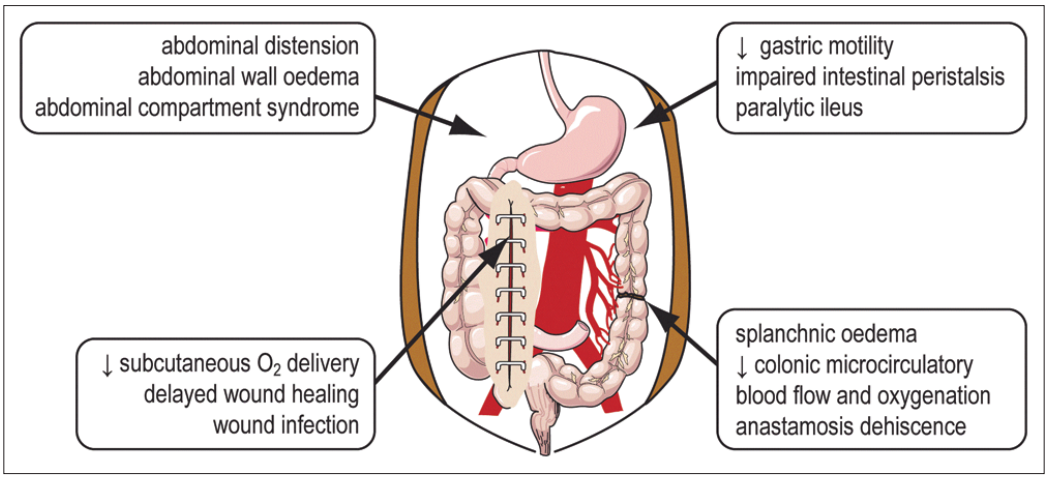


**Figure 3:** Fluid excess in colorectal surgical patients – pathophysiology and complications

### *Pathophysiology of fluid deficit and excess*

Colorectal surgical patients presenting for emergency surgery (e.g., due to obstruction or perforation) may present with severe fluid and electrolyte deficits because of insensible and sensible loss, prolonged starvation periods, and inadequate fluid therapy or resuscitation. Postoperative surgical complications such as paralytic ileus, anastomotic leak, and abdominal sepsis may further complicate fluid and electrolyte management. In these circumstances, the systemic fluid requirement may be higher, while the gastrointestinal fluid loss continues. Consequences of fluid overload may be delayed and are not easily recognizable in the immediate postoperative period [Figure 3]. In complicated colorectal surgical patients, fluid accumulation often occurs occultly within the lumen of the gastrointestinal tract or the abdominal cavity. Perioperative fluid and sodium excess must be avoided, as it is associated with gastrointestinal and systemic complications [Figure 3].[29,30]

### *Crystalloid or colloid?*

The crystalloid–colloid controversy continues for colorectal surgical patients. However, with an increased safety profile and their favorable pharmacokinetics, colloids are increasingly used in bowel surgical patients, particularly during GD therapy. In an experimental study, goal-directed colloid therapy was associated with a significant increase in microcirculatory blood flow and oxygen tension in the small intestine, and in healthy and perianastomotic colonic tissue.[31,32] In contrast, crystalloid administration, even in large amounts (20ml / kg), did not improve oxygen pressure in the small and large intestine.[33] In a comparative study of conservative (8mL·kg–1·h–1) versus aggressive (16 to 18 mL·kg–1·h–1) crystalloid fluid management, during open colon resection, intraoperative and postoperative subcutaneous tissue oxygen tension and capillary blood flow were found to be higher in the latter group.[34] However, large amounts of crystalloid are not recommended as mechanical bowel preparation, and prolonged fasting has become less common. Moreover, laparoscopic surgery is usually not associated with major fluid loss. Intraoperative high volume crystalloid therapy may result in increased bursting pressure and decreased structural stability of intestinal anastomoses, possibly due to bowel edema.[35]

In summary, during uncomplicated CR surgery, volume, type of fluid, and its timing of administration may affect its outcome. During the perioperative period of emergency colorectal surgery, fluid therapy is more challenging, because systemic, intestinal, and other regional responses to both fluid deficit and excess may be complex and diverse. A number of technical devices are available to optimize fluid therapy. However, there is no gold standard and magic formula or endpoint applicable to all patients. It is desirable to prevent fluid and sodium overload. Further studies are required to guide choice of fluids and to identify systemic and regional endpoints of fluid therapy and resuscitation.

## Blood transfusion

### *Correction of low Hb*

Preoperative anemia, mostly iron deficiency, is common in patients with colorectal cancer and inflammatory bowel disease. It is due to subclinical or clinical blood loss. Preoperative hemoglobin, blood loss, and local transfusion protocols are the key factors influencing allogenic transfusion.[36] For patients undergoing rectal resection for cancer, it has been found that age more than 65 years, obesity (body mass index > 27), preoperative hemoglobin less than or equal to 12.5 g / dL, and long duration of surgery (> 6 hours) are predictive of perioperative blood transfusion requirements.[37]

Oral ferrous sulfate, given preoperatively, to patients undergoing colorectal surgery offers a simple, inexpensive method of reducing the need for blood transfusions.[38] It has been suggested that patients with gastrointestinal tract

cancer and mild anemia may also benefit from perioperative erythropoietin as a means to reduce the need for blood transfusions.[39,40] A combination of iron and erythropoietin may be even more useful. However, a recent meta-analysis[41] concluded that there is no sufficient evidence to recommend pre- and perioperative erythropoietin use in colorectal cancer surgery. Intravenous iron and erythropoietin have been shown to be effective in Crohn's disease and ulcerative colitis–associated anemia. Acute normovolemic hemodilution is feasible for patients undergoing major colorectal surgery and is effective in reducing allogenic blood transfusion.[42]

### *Risks of blood transfusion*

Intraoperative blood transfusion in colorectal surgical patients is associated with an increased length of stay and higher cost.[43] Intraoperative blood transfusion due to blood loss is associated with a more exaggerated immune response in comparison to preoperative blood transfusion due to anemia.[44] Increased L-6 and associated tumor growth factors may affect the prognosis after curative surgery for colorectal cancer.[44] Perioperative blood transfusion is also associated with increased colorectal recurrence rates.[45] Allogenic blood transfusion is also an independent risk factor for developing postoperative infections most likely secondary to immunosuppression.[46] Blood transfusions should, therefore, be administered with strict indications only. Heiss *et al.*[47] suggested that a change in the practice of blood transfusion might potentially surpass the impact of any adjuvant treatment strategies.

## Critical care

Intestinal blood flow (IBF) and intestinal oxygen delivery (IOD) are important for normal physiological functions, such as, absorption of nutrients and formation and excretion of feces. In addition, during the perioperative period optimal IBF and IOD are needed to preserve the mucosal barrier function, peristalsis, and healing of anastomosis. IBF and IOD may be affected by a wide range of factors in critically ill colorectal surgical patients.

However, the IBF and IOD are not well-researched in clinical settings. Most studies are experimental, of short duration and carried out in different species with limited physiological or pathological challenge. Effects of anesthetic agents, fluid therapy, and vasopressors on IBF and IOD are not well known in humans. Colon blood flow (CBF) and oxygenation are controlled by a number of local, regional, and systemic factors. Flow auto-regulation is more pronounced in the villus circulation than in the muscle layers.[48] Total colon blood flow may vary greatly with blood pressure changes.[49] However, oxygen uptake in the presence of hypotension is maintained because of capillary recruitment and local vasodilatation. Autoregulatory escape has been demonstrated following both physiological and pharmacological sympathetic activation.[50] The mechanisms responsible for autoregulatory escape have not been well-identified.

Critical changes in colon blood flow and oxygenation may occur without changes in other splanchnic organs (e.g., stomach) and systemic tissues (e.g., muscle). In some critical conditions, such as sepsis and hemorrhage, blood flow redistribution within the colonic wall can also occur.[51,52] Patients presenting in septic shock for emergency surgery may have a 50% reduction in their colon microcirculatory blood flow. In a porcine model, postoperative intestinal blood flow was 25% below baseline, despite adequate volume status.[53] Increased intra-abdominal pressure causes significant decrease in bowel submucosal $pO_2$ without similar changes in extra-abdominal (subcutaneous) $pO_2$.

Strategies to improve IBF and IOD are not well defined. Fluid therapy and vasopressors / inotropes have been used to optimize IBF and IOD. However, there is no ideal fluid and / or inotrope, and no ideal method to evaluate their effects on IBF and IOD. Intestinal mucosal pH, intestinal luminal PCO2, and hepatic venous saturation and lactate concentrations have been suggested as markers of intestinal hypoperfusion.[54] It is beyond the scope of this article to discuss in detail the critical care of bowel surgical patients. However, in critically ill, complicated colorectal surgical patients, careful clinical examination and evaluation, interpretation of monitored parameters to judge fluid / inotrope responsiveness, and timely resolution of surgical and medical complications are more important than specific technological tools.

## Morbidity and mortality

Colorectal surgery is a high-risk surgery and associated with significant morbidity and mortality. *Major preoperative risk factors* for post colorectal surgery complications include age (> 75),[55] ASA grade (> 2),[56] pre-existing comorbidities (e.g., cardiorespiratory),[57] low functional capacity as measured by the cardiopulmonary exercise test (CPET),[58] reduced preoperative nutritional status[59,60] (e.g., anemia, hypoproteinemia, weight loss), smoking,[59] obesity,[60] type of surgery, and its indication (e.g., elective vs. emergency, cancer vs. non-cancer, right- vs. left-sided lesions), and presence of shock (in case of emergency surgery). *Important intraoperative risk factors* for postoperative complications are duration of surgery[61] (for both laparoscopic and open surgery), blood loss and blood transfusion,[62] open vs laparoscopic procedure, conversion to open procedure (in case of laparoscopy),[63] Mannheim peritonitis index,[19] Hinchey

grade for perforation,[64] presence of shock, hypothermia, excessive fluid and sodium administration, and surgical Apgar score[65] (based on blood loss, lowest heart rate, and lowest mean arterial blood pressure). *Postoperative risk factors* for developing complications are conventional recovery pathways (compared to enhanced recovery), inadequate pain relief, excessive fluid and sodium administration,[30] low $ScvO_2$, sepsis, and late enteral feeding.

The *individual* surgeon's practice,[66] and skills (e.g., number of cases, bowel preparation, handling of intraoperative complications, surgical technique), experience of the anesthesiologist,[67] and *organizational*[68] (e.g., access to high quality hospitals) and *institutional factors* (e.g., hospital procedure volume,[69] delays in surgery) also influence the rate of complications. The perioperative factors mentioned are part of various predictive models for death related to colorectal surgery, such as, the POSSUM score and its variants, the ACPGBI model or the Cleveland clinic foundation colorectal cancer model.[70]

Quality improvement measures,[71,72] such as, implementation of care pathways (e.g., enhanced recovery), preoperative optimization of medical problems, prompt recognition and management of complications and their risk factors, developing institutional and organizational capabilities (e.g., multidisciplinary teams, availability of critical care beds), and experienced and skillful teams, are expected to improve morbidity and mortality.

### *Mortality*

In the UK, the overall postoperative mortality rates continue to decrease (from 7.04% in 2001 to 4.3% in 2008). This may be due to a number of factors, including a better selection of patients who will tolerate and benefit from major surgery, improvements in service infrastructure to provide optimal postoperative care, and better surgical technique. The all-cause, 30-day mortality rate for elective / scheduled procedures was 3.0% and for urgent / emergency procedures it was 10.8%. It is variable among various hospitals.

In a large study from the US, Davila *et al.*[73] found the 30-day postoperative mortality to be reduced from 4.7% (1987 – 1988) to 3.9% (1998 – 2000), resulting in a 22% lower mortality risk for colorectal cancer patients. Reduced mortality rates were attributed to a reduction in complications such as thromboembolism, anesthesia-related complications, and advances in surgical techniques. A French multicenter study by Alves *et al.*[74], comprising 1421 colorectal surgery patients, found a similar mortality rate of 3.4%. Important causes of in-hospital deaths were septic shock, terminal cancer, cardiac failure, bronchopneumonia, and acute respiratory distress, myocardial infarction, multi-organ failure, gastrointestinal hemorrhage, and stroke. The 30-day, in-hospital mortality, during emergency surgery is three to four times higher in comparison to elective surgery.[13,14] It may further increase two- to three-fold at the end of one year, depending on the primary pathology (e.g., cancer or non-cancer).[14]

### *Morbidity*

The overall morbidity (medical or surgical complications) after emergency CR surgery is 3 to 10 times higher than morbidity after elective surgery. The incidence of complications varies from 13 to 37% in most studies after CR surgery.[74]

## Medical complications

A wide variety of medical complications can occur after bowel surgery, with cardiovascular and pulmonary complications being the most frequent. Lawrence *et al.* found a complication rate of 9.6% for pulmonary complications and 5.7% for cardiac complications in patients after abdominal surgery.[75]

Typical cardiac complications are supraventricular and ventricular dysrhythmias, congestive heart failure, and myocardial infarction.[76] Typical postoperative pulmonary complications after a major colorectal surgery, are acute respiratory failure, pneumonia, effusions, and atelectasis. Risk factors and risk-reduction strategies for cardiac and pulmonary complications including perioperative optimization and the choice of anesthetic technique have been extensively reviewed.[76]

Postoperative bowel surgery patients are at risk of further medical complications, such as thromboembolic events, renal impairment, and neurological events. Close postoperative monitoring, correction of fluid and metabolic imbalances, and application of standard prophylactic measures (such as anticoagulants) are essential to limit these complications to a minimum. Fleming *et al.*[77] analyzed data from 52555 patients, following major colorectal surgery, with regard to the incidence of post-discharge deep venous thrombosis (DVT) and pulmonary embolism (PE). Even as the overall incidence of DVT was 0.47%, and incidence of PE was 0.26%, they identified obesity, preoperative steroid use, coagulation disorders, ASA class III, and postoperative complications, as independent factors, for a significantly raised risk of thromboembolism, suggesting prolonged prophylactic treatment for selected patients. Patients in renal failure have a significantly raised complication risk after bowel surgery, due to uremia and immunosuppression. Krysa and Patel[78] found the risk of infection to be 60% in this population. Another frequent complication after abdominal

**Table 1: Common postoperative complications after colorectal surgery**

| Complication (references) | Incidence | Risk factors | Clinical features | Prevention | Management | Comments |
|---|---|---|---|---|---|---|
| Paralytic ileus[84,85] | Considered (almost) inevitable after abdominal surgery | Open surgery<br>Emergency surgery<br>Higher ASA grade<br>Fluid excess | Abdominal distention<br>Lack of bowel sounds<br>Delayed passage of feces and flatus | -Early enteral feeding<br>-Opioid sparing analgesia<br>-Epidural Anesthesia<br>-Laparoscopic surgery<br>-Avoid NG-tubes | -Peripheral opioid antagonists<br>-Laxatives, Prokinetics (effectiveness unclear)<br>-Correct the cause e.g. hypokalemia, hypomagnesemia<br>-review medications | Multimodal approach can reduce its incidence, severity and duration |
| Anastomotic leak[86-89] | 2 – 4% intraperitoneal anastomoses<br>8 – 12% infraperitoneal anastomoses | Impaired microcirculation (angiopathy, smoking, CAD)<br>Sepsis<br>Higher ASA grade<br>Emergency surgery<br>Hypoproteinemia (serum protein < 5.5 g / dl), anemia (Hb < 9.4 g / dl) | Asymptomatic (with radiological diagnosis)<br>Local abscess<br>Fecal discharge from wounds / drains<br>Generalized peritonitis | -Meticulous surgical technique, staged procedures, protective stomata<br>-Sufficient nutritional support<br>-Avoid MBP, NG tube, drains | -Conservative (surveillance, antibiotic treatment)<br>-Abscess drainage<br>-Re-anastomosis | Increases mortality and LOS significantly.<br>May increase risk of recurrence of cancer.<br>Effects of type of fluid, epidural analgesia and various experimental therapies (e.g., use of growth factors) not established |
| Wound infection[90,91] | 4.7 – 26% | Preoperative steroids<br>Preoperative radiotherapy<br>Higher ASA grade<br>Diabetes<br>Wound contamination<br>Rectal, left colon surgery<br>Operation > 3 hours<br>Perioperative blood transfusion | Local inflammation<br>Delayed wound healing<br>Abscess formation<br>Dehiscence<br>Systemic infection (sepsis) | -Antibiotic prophylaxis<br>-Laparoscopic surgery<br>-Meticulous surgical technique<br>Meticulous wound care<br>-Prevent perioperative hypothermia<br>-Supplemental oxygen | -Antibiotic treatment as per culture and sensitivity<br>-Abscess drainage<br>-Wound revision / debridement | Increases LOS (21 ± 15 days, compared to 6 ± 4 days) |
| Abdominal compartment syndrome[92,93] | Unclear in bowel surgery patients | Emergency procedures<br>Abdominal trauma<br>Large volume fluid resuscitation<br>Bowel edema<br>Tense abdomen closure, packing | Hypoventilation, respiratory failure<br>Reduced cardiac output<br>Gastrointestinal organ failure<br>High mortality | -Avoid risk factors where possible<br>-Abdominal pressure measurement | -Decompressive laparotomy | - |

surgery is postoperative delirium, with an incidence of 25 – 35%, especially in the older patient population.[79] This incidence, after CR surgery, has been found to be 21% during the first 24 hours, and it persists for up to three days in 7% of the cases.[80] In patients with general risk factors for delirium during hospitalization (severe illness, visual impairment, cognitive impairment, renal impairment), this incidence can be significantly higher. Strategies to avoid postoperative delirium include preoperative optimization of nutritional and functional status (e.g., mobilization), as well as adequate perioperative nutritional support and strict control of hyperglycemia.[81] Brouquet *et al.*[82] also identified postoperative tramadol administration as a strong risk factor for delirium in elderly patients, and recommended avoidance of tramadol and other atypical opioids (e.g., pethidine) in this group.

Postoperative urinary retention is a frequent complication after bowel surgery, the incidence being described with 1.7% in colon cancer patients, and 9.1% in rectal cancer patients. Old age, long operations, and additional pelvic procedures added to the risk of urinary retention.[83]

## Surgical complications

Common postoperative complications, their risk factors, and preventive strategies are summarized in Table 1.

## Conclusion

Perioperative outcome after elective colorectal surgery has improved due to increased awareness and application of evidence-based and enhanced recovery care principles.[94] Peri-operative morbidity and mortality in emergency and complicated colorectal surgical patients remain significantly high. Abdominal sepsis is a serious complication leading to multi-organ failure and death in emergency cases. Effects of anesthetic agents on intestinal blood flow and oxygenation in the presence of gastrointestinal sepsis and vasopressors are not known. Timely surgical intervention and prompt and prudent perioperative management by experienced and multidisciplinary staff in a critical or high dependency care environment may minimize the morbidity and mortality. Large volume fluid therapy may lead to gastrointestinal and systemic complications. Anesthesiologists could play an important role to improve the outcome of high risk and emergency cases, by provision of balanced fluid therapy and systemic and intestinal circulatory management. However, therapeutic strategies and endpoints to achieve these goals are not well-defined for emergency and complicated colorectal surgical patients.

### Contribution by authors

SP conceptualized the article. SP designed the overall structure, figures, and tables for part 1 and part 2. SP searched and collected literature for all sections. SP responded to reviewers' comments and was responsible for revisions and correspondence for both parts. JL and SP wrote the emergency surgery and morbidity and mortality sections. SP wrote the fluid therapy, blood transfusion, and critical care sections. All authors contributed to the organization of references and approved the final revision.

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