

Research Advances in the Prevention of Postoperative Anastomotic Leakage in Colorectal Cancer

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Abstract

According to the 2022 Global Cancer Statistics, colorectal cancer ranked third in new cancer cases and second in cancer-related deaths globally in 2022. Surgical treatment is a key treatment modality for patients with colorectal cancer. Although significant advancements have been made in surgical techniques, perioperative interventions, and treatment measures over the years, postoperative complications such as anastomotic leakage, intra-abdominal infection, and poor incision healing still inevitably occur. Among these, colorectal anastomotic leakage (CAL) is a particularly severe surgical complication, with an incidence rate as high as 30%. The occurrence of anastomotic leakage can lead to intra-abdominal and systemic infections, prolonged hospital stay, increased medical burden, worsened prognosis, and decreased survival rate in patients. Additionally, anastomotic leakage is a significant contributing factor to reoperation within 30 days after laparoscopic colorectal cancer resection, with a reoperation rate of 64.8%. Therefore, the prevention of postoperative anastomotic leakage in colorectal cancer is particularly important. This article reviews the research progress in the clinical prevention of postoperative anastomotic leakage in colorectal cancer.

Keywords

Colorectal Neoplasms, Anastomotic Leakage, Prevention

1. Anastomotic Leakage

1.1. Definition

According to the definition of the International Rectal Cancer Study Group, anas-

tomotic leakage is defined as: a complication in which, after the completion of intestinal anastomosis in colorectal surgery, intestinal contents (such as digestive juices, feces, etc.) leak through the anastomosis into the extraintestinal abdominal cavity or surrounding tissues due to poor healing or defects at the intestinal anastomotic site [1].

1.2. Diagnosis

Anastomotic leakage after colorectal cancer surgery can be confirmed through clinical manifestations, imaging examinations, and surgical or endoscopic exploration [2]. In clinical practice, patients with intra-abdominal infection caused by anastomotic leakage may present with fever and tachycardia; in severe cases, they may experience peritonitis, sepsis, or even shock and coma. Meanwhile, digestive fluid or intestinal contents containing fecal residues may be drained from the abdominal drainage tube. Imaging examinations can be further confirmed by performing an abdominal plain CT scan after oral administration of intestinal contrast agents such as meglumine diatrizoate postoperatively. Imaging findings often show characteristics such as peritoneal effusion, exudation around the anastomosis in the abdominal cavity, or contrast agent leakage. Secondary surgical exploration or colonoscopy can detect visible anastomotic defects, gaps, or other signs of poor anastomotic integrity, as well as accumulation of intestinal contents around the anastomosis.

1.3. Classification of Anastomotic Leakage

The International Rectal Cancer Study Group classifies anastomotic leakage into three grades based on severity [1]. Grade A anastomotic leakage, clinically also referred to as radiological anastomotic leakage, is mild in severity. Patients usually have no specific clinical symptoms of discomfort, and conservative treatment is often adopted without the need for special intervention. Grade B anastomotic leakage: patients may present with symptoms such as fever and peritonitis. Laboratory tests may show elevated infection indicators such as white blood cells, neutrophils, C-reactive protein (CRP), and procalcitonin (PCT). Treatment requires nil per os (NPO), fluid replacement, anti-infective therapy, and continuous negative pressure irrigation through abdominal drainage tubes, among other treatments. Grade C anastomotic leakage: intra-abdominal infection is severe; in severe cases, it may present with sepsis, shock, or even coma. Treatment requires intervention measures such as secondary surgery for re-anastomosis of the intestine or an intestinal stoma.

1.4. Related Risk Factors for Anastomotic Leakage

Current studies have indicated that multiple perioperative risk factors are considered to be closely associated with the occurrence of postoperative anastomotic leakage [3], such as male gender, elevated ASA classification ($ASA \geq II$ or III), high body mass index (e.g., $BMI \geq 30$), smoking, alcohol consumption, and un-

derlying diseases (e.g., diabetes mellitus, hepatic or renal insufficiency, hypoalbuminemia, etc.); furthermore, excessive intraoperative blood loss, too short a distance between the anastomosis and the anal verge (<5 cm), postoperative anastomotic bleeding, and hypoxemia caused by deteriorated cardiopulmonary function after surgery, etc.

2. Prevention of Anastomotic Leakage

2.1. Preoperative Preventive Measures

2.1.1. Bowel Preparation

Bowel preparation is a routine preoperative procedure for elective surgery of colorectal cancer. A meta-analysis published in 2018 [4] indicated that mechanical bowel preparation alone failed to significantly reduce the incidence of postoperative anastomotic leakage when no antibiotics were used preoperatively ($P = 0.32$). Current studies and meta-analyses [5] [6] have shown that preoperative mechanical bowel preparation combined with oral antibiotics plays a positive role in preventing anastomotic leakage after colorectal surgery. Meanwhile, the studies also pointed out that compared with bowel preparation alone, combined oral antibiotics can reduce the occurrence of postoperative complications such as poor wound healing, infection, and intestinal paralysis. The American Practice Guidelines for Bowel Preparation in Colorectal Surgery published in 2019 [7] state that it is recommended to perform bowel preparation plus oral antibiotics before elective colorectal surgery, and the guidelines also note that mechanical bowel preparation alone without oral antibiotics is not recommended. A domestically published protocol for preoperative bowel preparation in elective surgery of colorectal cancer in 2022 [8] points out that it is recommended that colorectal cancer patients with no gastrointestinal obstruction or incomplete obstruction (without typical symptoms of intestinal obstruction) undergo bowel preparation combined with oral antibiotics before elective surgery. Based on the above research conclusions, bowel preparation combined with oral antibiotics before colorectal surgery can prevent the occurrence of postoperative anastomotic leakage.

2.1.2. Application of Stent Placement in the Treatment of Colorectal Cancer Complicated by Acute Intestinal Obstruction

Colorectal stent implantation can effectively relieve the symptoms of intestinal obstruction in patients with colorectal cancer complicated by acute intestinal obstruction, thereby providing conditions for bowel preparation. A study by Zhang Hongsheng *et al.* [9], which included a total of 102 patients with obstructive colorectal cancer, showed that compared with emergency surgery to relieve intestinal obstruction, the incidence of anastomotic leakage was significantly reduced in patients who underwent stent placement followed by elective surgery. Another study [10] reported that in 46 patients with colorectal cancer complicated by acute intestinal obstruction who underwent intestinal stent placement followed by elective surgery after the symptoms of intestinal obstruction were relieved, no anastomotic

leakage occurred after surgery. These study results indicate that stent placement can effectively reduce the incidence of postoperative anastomotic leakage in patients with colorectal cancer complicated by acute intestinal obstruction.

2.2. Intraoperative Measures for the Prevention of Anastomotic Leakage

2.2.1. Inferior Mesenteric Artery Ligation Level

In surgical treatment of rectal cancer, the positions for ligating the Inferior Mesenteric Artery (IMA) can be divided into two types: one is high-ligation (HT) at the root of the IMA, and the other is ligation distal to the origin of the Left Colonic Artery (LCA), namely low-ligation (LT), which preserves the left colonic artery. A study by Zhang Haiqing *et al.* [11], which included 120 patients with rectal cancer who underwent laparoscopic anterior resection and received high or low ligation of the IMA under precise CT guidance, showed that the incidence of anastomotic leakage in the low-ligation group was significantly lower than that in the high-ligation group [3.85% (2/52) vs 13.24% (9/68)]. A study by Komen *et al.* [12], which included patients undergoing rectal resection for malignant tumors, measured the blood supply of the colonic stump after surgery using a laser Doppler flowmeter, and the results showed that the blood flow ratio in the LT group was significantly higher than that in the HT group. Another study by Teng Wenhao *et al.* [13], which included rectal cancer patients who underwent surgery after neoadjuvant therapy, showed that the incidence of anastomotic leakage after low ligation was lower than that after high ligation. The above research results indicate that when managing the left colonic artery during surgery, low ligation can maximally preserve blood perfusion to the anastomotic stoma, provide better healing conditions for anastomotic healing, and reduce the occurrence of anastomotic leakage.

2.2.2. Pedicled Greater Omentum for the Prevention of Anastomotic Leakage

Some scholars pointed out in a study [14] on patients with colorectal cancer complicated by intestinal obstruction undergoing surgery that to prevent postoperative anastomotic leakage, an intraoperative pedicled greater omentum protection strategy was adopted: the pedicled greater omentum was freed and wrapped around the intestinal anastomosis, and the occurrence of anastomotic leakage was statistically analyzed postoperatively. The results showed that the incidence of anastomotic leakage was only 2% in patients who received omental wrapping, while it was as high as 12% in the control group without protective measures, and the difference between the groups was statistically significant ($\chi^2 = 4.250$, $P = 0.039$).

In their study, Li Xing *et al.* [15] divided patients into an observation group (intervention implemented) and a control group (no intervention implemented) according to whether the anastomosis was wrapped with free pedicled greater omentum intraoperatively. The results suggested that wrapping the anastomosis

with free pedicled greater omentum could significantly reduce the risk of anastomotic leakage after colorectal cancer surgery, with a statistically significant difference ($P < 0.05$).

The greater omentum in the human abdominal cavity is rich in lymph nodes, lymphatic vessels, and immune cells such as macrophages, lymphocytes, and plasma cells. Wrapping the anastomosis with free pedicled greater omentum can form a barrier around the anastomosis, promote inflammation absorption, inhibit the spread of inflammation and infection, and reduce the risk of intestinal leakage. In addition, the greater omentum has a rich vascular network; when the local blood supply of the anastomosis is poor, it can form a blood supply anastomosis with the anastomosis area through its own blood vessels, provide blood supply support, and assist in the repair of anastomotic tissue.

Based on the above research results, wrapping the anastomosis with a pedicled greater omentum intraoperatively can not only promote anastomotic healing but also reduce the risk of postoperative anastomotic leakage.

2.2.3. Anastomotic Reinforcement Suture

In laparoscopic rectal cancer surgery, after resection of the tumor-bearing intestinal segment and intestinal reconstruction (*i.e.*, intestinal anastomosis), if the diameters of the intestinal segments at both ends of the anastomosis are inconsistent or the stapler is used improperly, protrusions or folds are likely to form at the anastomotic margin. This area is prone to poor blood supply, inadequate suturing, and uneven tension, making it a high-risk area for anastomotic leakage, also known as the “dog-ear area”. Therefore, reducing anastomotic tension, strengthening weak areas, and decreasing the occurrence of anastomotic leakage have become key research focuses in colorectal surgery.

A study [16] reported that among 291 patients who underwent laparoscopic radical resection of rectal cancer included in the study, the incidence of anastomotic leakage was 5 cases (3.4%) in the anastomotic reinforcement suture group and 17 cases (11.6%) in the conventional suture group, with a statistically significant difference ($\chi^2 = 6.992$, $P = 0.008$). Meanwhile, when stratified and classified according to risk factors, in patients with high-risk factors, the incidence of anastomotic leakage was 6.2% (2/32) in the reinforcement suture group and 27.1% (13/48) in the non-reinforced suture group. In the low-risk factor group, the incidence rates of anastomotic leakage in the reinforcement suture group and non-reinforced suture group were similar [4.1% (4/98) vs 2.7% (3/113), $\chi^2 = 0.333$, $P = 0.564$].

A retrospective case-control study [17] included 602 patients who underwent laparoscopic anterior resection of rectal cancer. By comparing data from two groups with and without intraoperative anastomotic reinforcement suture, it was found that 6 cases of postoperative anastomotic leakage occurred in the reinforcement suture group (253 cases), with an incidence of 2%; while 21 cases occurred in the non-reinforced suture group (349 cases), with an incidence of 6%, and the difference between the groups was statistically significant ($\chi^2 = 4.56$, $P < 0.05$).

The above research results indicate that anastomotic reinforcement suture helps

reduce local anastomotic tension, thereby decreasing the occurrence of anastomotic leakage. However, the number of cases included in the above studies is limited, and future large-sample prospective randomized controlled trials are still needed for further verification.

2.2.4. Anastomotic Stent for the Prevention of Postoperative Anastomotic Leakage

A study [18] indicated that a specific specification of intrainestinal nickel-titanium memory alloy stent (developed by Zhiye Medical Instrument Research Institute, Changzhou City, Jiangsu Province) was used intraoperatively. In patients with rectal cancer, the stent was placed in the anastomotic area after intestinal anastomosis, and the occurrence of anastomotic leakage was compared between the postoperative stent placement group and the non-stent placement group. Data showed that the incidence rate of anastomotic leakage in the non-stent placement group was 16.9%, while no cases of anastomotic leakage occurred in the stent placement group after surgery, and the difference was statistically significant ($P = 0.002$).

Meanwhile, the study also reported adverse effects after stent implantation, such as intrarectal pain, rectal irritation symptoms, and intrarectal foreign body sensation after surgery. However, the number of included cases in this study was small, and there are many factors affecting postoperative anastomotic healing, such as hypoalbuminemia, excessive intraoperative blood loss, and postoperative anastomotic bleeding. The effect of anastomotic stent implantation in preventing anastomotic leakage still needs to be confirmed by more clinical reference studies.

2.2.5. Indocyanine Green Imaging for Prevention of Anastomotic Leakage

Good blood supply condition is an important factor in reducing the occurrence of anastomotic leakage [19]. Indocyanine green fluorescence imaging (ICG-FI) has important application value in laparoscopic colorectal surgery. It can assist surgeons in accurately locating the intestinal segment to be transected, effectively evaluating the blood supply in the anastomotic area, and thereby reducing the risk of postoperative intestinal anastomotic leakage [20]. During surgery, after mobilizing the intestinal segments at both ends of the tumor, indocyanine green is injected via a peripheral vein. Under laparoscopic fluorescence mode, the blood supply of the mobilized intestinal segments at both ends is assessed, the resection range of the intestinal segment is adjusted based on the imaging, and the blood supply of the anastomosis can also be evaluated after completing the intestinal anastomosis [21]. However, recent studies have held different views on the role of indocyanine green in preventing anastomotic leakage.

A recent systematic review and meta-analysis [22] involving 8786 patients (48.5% male) showed that compared with the non-ICG group, the incidence of anastomotic leakage in the intraoperative ICG group was significantly lower (OR = 0.452, 95% CI: 0.366 - 0.588), and the complication rate was also significantly reduced (OR = 0.747; 95% CI: 0.592 - 0.943). A randomized clinical trial conducted in Ja-

pan [23], which included 839 rectal cancer patients undergoing minimally invasive sphincter-preserving surgery, demonstrated that the total incidence of anastomotic leakage in the ICG group was lower than that in the non-ICG group (7.6% vs 11.8%, $P = 0.041$). The incidence of (Grade B + C) anastomotic leakage was (4.7% vs 8.2%, $P = 0.044$), and the reoperation rates were (0.5% vs 2.4%, $P = 0.021$), respectively.

A single-center randomized trial conducted by Alekseev *et al.* [24] included 377 patients undergoing sigmoid colon or rectal resection. The results showed that in terms of the total incidence of anastomotic leakage (including Grades A, B, and C), the total incidence in the ICG group and non-ICG group was 9.1% and 16.3%, respectively, with a statistically significant difference ($P = 0.04$). Meanwhile, among patients with low anastomosis (4 - 8 cm from the anus) in this study, the incidence of anastomotic leakage in the ICG group was significantly lower than that in the non-ICG group (14.4% vs 25.7%, $P = 0.04$).

Currently, multiple literature sources and studies [25]-[29] have reported the positive role of indocyanine green in reducing postoperative anastomotic leakage and complications in colorectal cancer. However, the results of a recent "PILLAR III" study [30] showed that although indocyanine green can visualize anastomotic blood perfusion, it failed to reduce the incidence of anastomotic leakage (9.0% vs 9.6%, $P = 0.37$). The first randomized controlled trial applying indocyanine green in colorectal cancer surgery was completed by De Nardi *et al.* [31], which included 240 patients undergoing laparoscopic colorectal resection. They were divided into ICG group and non-ICG group according to whether indocyanine green was used intraoperatively. The results showed that anastomotic leakage occurred in 11 cases (9%) in the non-ICG group and only 6 cases (5%) in the ICG group, with no statistically significant difference between the two groups ($P = n.s.$).

However, the assessment of anastomotic blood supply via ICG-FI technology is highly dependent on the surgeon's subjective perception and experience. Additionally, there is a lack of standardized methods and indicators for evaluating anastomotic blood supply using ICG-FI technology, and there are no standardized criteria for the optimal operation time and observation distance when applying ICG-FI during surgery. Therefore, the above conclusions indicate that the application of indocyanine green may reduce the occurrence of anastomotic leakage, but larger-sample, multicenter studies are needed in the future to provide higher-quality medical evidence support.

2.2.6. Postoperative Indwelling of Anal Tube for Prevention of Anastomotic Leakage

In recent years, literature has reported that indwelling an anal tube after laparoscopic rectal cancer surgery is used to prevent anastomotic leakage. Huang Haibin *et al.* [32] conducted a case-control study, including 71 patients who underwent laparoscopic radical resection of rectal cancer. They were divided into the study group (indwelling a silicone or ordinary anal tube 5 - 10 cm proximal to the intestinal anastomosis postoperatively) and the control group (no indwelling) based

on whether an anal tube was indwelled postoperatively. The occurrence of postoperative anastomotic leakage was compared between the two groups. The results showed that no cases of anastomotic leakage occurred in the study group, while the incidence in the control group was 12%, with a statistically significant difference ($P < 0.05$).

A meta-analysis published in 2021 [33] included 2 randomized controlled trials and 13 observational studies, involving 1714 patients with indwelling anal tubes and 1741 patients without indwelling anal tubes after anterior resection of the rectum. The results showed that the incidence of anastomotic leakage in the anal tube indwelling group was lower than that in the non-indwelling group (7% vs 12.3%, $P < 0.001$). Meanwhile, the incidence of anastomotic leakage complications requiring surgical intervention was also lower than that in the non-indwelling group (2.9% vs 8%, $P < 0.001$).

However, a meta-analysis published in 2023 [34] investigated the preventive effect of indwelling anal tube drainage on anastomotic leakage after rectal cancer surgery. Comparing two groups of patients with and without indwelling anal tube drainage postoperatively, the results indicated that the former did not significantly reduce the total incidence of anastomotic leakage (5.5% vs 7.9%, $P = 0.12$) or the incidence of Grade B anastomotic leakage (4.5% vs 3.8%, $P = 0.56$). However, this analysis pointed out that compared with non-indwelling anal tube drainage, the incidence of Grade C anastomotic leakage (1.6% vs 4.5%, $P = 0.003$) and reoperation rate (0.9% vs 4.3%, $P = 0.001$) after indwelling anal tube drainage were both lower. This study further indicated that indwelling anal tube drainage after radical resection of rectal cancer has an indefinite effect in reducing the total incidence of anastomotic leakage, but has potential clinical benefits for patients with Grade C anastomotic leakage.

Meanwhile, in view of the poor performance of indwelling a single silicone drainage tube postoperatively in preventing anastomotic leakage, such as the occurrence of lumen stenosis, blockage, or poor drainage, some teams have attempted to use dual silicone drainage tubes to prevent anastomotic leakage. Sun Shaowei *et al.* [35] used dual silicone tubes for indwelling intra-anal drainage postoperatively, and among 131 patients who underwent laparoscopic anterior resection of rectal cancer, only 3 cases developed anastomotic leakage (2.3%). Because dual anal tube drainage is relatively unobstructed, lumen blockage is relatively rare, and there is no need for intermittent postoperative irrigation. This study also indicated that indwelling anal tube drainage postoperatively can still play a role in preventing anastomotic leakage on the premise of ensuring no lumen blockage, stenosis, and unobstructed drainage.

However, postoperative indwelling of the anal canal can lead to a series of problems, such as lumen obstruction, poor drainage, etc. Additionally, there is no unified standard for the type, size, and postoperative indwelling time of the indwelling anal canal. Therefore, the use of postoperative indwelling anal canal for preventing anastomotic leakage still requires higher-quality studies to provide high-

quality evidence-based medical evidence.

2.2.7. Prophylactic Stoma

Prophylactic stoma, also known as diversionary stoma, aims to divert feces through the stoma and is commonly used clinically in patients with rectal tumors complicated by intestinal obstruction or poor general condition [36]. The clinical value of prophylactic stoma in reducing the incidence of anastomotic leakage remains controversial.

Opponents argue that the three main factors affecting postoperative anastomotic leakage are poor anastomotic blood supply, excessive tension, and poor local condition of the intestinal tract. The causes of these factors include: diabetes mellitus, anemia, hypoalbuminemia, use of targeted drugs, long-term smoking history, failure to preserve the left colic artery during surgery, injury to the marginal arterial arcade, anastomotic site too close to the anus, preoperative presence of intestinal obstruction, adequacy of bowel preparation, preoperative administration of neoadjuvant therapy, etc. Prophylactic stoma has little impact on the above-mentioned causes; meanwhile, prophylactic ileostomy does not affect the mobilization of the left colon and sigmoid colon, and thus has no significant association with anastomotic tension [37].

Some studies [37] [38] have suggested that a prophylactic stoma may reduce the direct stimulation of intestinal contents on the anastomosis through fecal diversion, while relieving mechanical tension and intraluminal pressure in the anastomotic area, maintaining the structural stability of the anastomosis, thereby reducing the risk of postoperative anastomotic leakage to a certain extent. Another retrospective study [39] showed that among 4282 patients who underwent low anterior resection, 232 out of 1367 patients who received a protective stoma developed anastomotic leakage, with an incidence of 5.4%; compared with those without a stoma, a protective stoma reduced the incidence of anastomotic leakage (HR = 0.334, 95%CI = 0.212). However, a retrospective analysis of 5398 rectal cancer patients by Degiuli *et al.* [40] showed that although a prophylactic stoma did not reduce the occurrence of anastomotic leakage, it could alleviate the severity after leakage and reduce the reoperation rate. Based on the above studies, a prophylactic stoma may reduce the incidence of anastomotic leakage, and for anastomotic leakage that has occurred, it can alleviate its severity and reduce the probability of secondary surgery.

3. Summary

With the advancement of medical technology and diagnostic and therapeutic capabilities, the popularization of the concept of comprehensive cancer treatment, and the improvement and development of medical anastomotic devices, the incidence of anastomotic leakage has not significantly decreased, highlighting the persistent gap between clinical practice and ideal goals. How to reduce the occurrence of anastomotic leakage remains a key focus of clinical research. For clinicians, it is

necessary to practice the “whole-course and individualized” prevention and treatment philosophy, such as conducting preoperative systematic assessment of patients’ nutritional status, controlling their underlying diseases, and ensuring effective bowel preparation. During surgery, the principles of “tension-free, adequate blood supply, and proficient technique” should be followed, including reducing intraoperative blood loss, shortening surgical duration, and using ICG to accurately assess anastomotic blood supply. Postoperatively, dynamic monitoring of patients’ body temperature, infection indicators, and abdominal signs should be performed, and if necessary, timely examinations such as gastrografin contrast radiography should be conducted to promptly detect potential anastomotic leakage.

Currently, for the prevention of anastomotic leakage, there is still a lack of high-quality, multicenter prospective clinical studies in clinical practice. In the future, rigorously designed prospective studies are needed to further clarify prevention strategies and accumulate higher-quality evidence-based medical evidence. Meanwhile, colorectal surgeons should actively participate in clinical research, build databases through case data accumulation, explore higher-quality evidence-based medical evidence, and ultimately achieve the goals of reducing complications such as anastomotic leakage, shortening hospital stays, and improving long-term quality of life, thereby benefiting a large number of patients.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] Rahbari, N.N., Weitz, J., Hohenberger, W., Heald, R.J., Moran, B., Ulrich, A., *et al.* (2010) Definition and Grading of Anastomotic Leakage Following Anterior Resection of the Rectum: A Proposal by the International Study Group of Rectal Cancer. *Surgery*, **147**, 339-351. <https://doi.org/10.1016/j.surg.2009.10.012>
- [2] Chen, W.J. and Lin, G.L. (2021) Current Status and Prospects of Diagnosis and Treatment of Anastomotic Leakage after Low Anterior Resection for Rectal Cancer. *Chinese Journal of Gastrointestinal Surgery*, **24**, 493-497.
- [3] Colorectal Surgery Group, Chinese Society of Surgery and Chinese Medical Association (2019) Expert Consensus on Diagnosis, Prevention, and Management of Anastomotic Leakage After Rectal Cancer Surgery in China (2019 Edition). *Chinese Journal of Gastrointestinal Surgery*, **22**, 201-206.
- [4] Rollins, K.E., Javanmard-Emamghissi, H. and Lobo, D.N. (2018) Impact of Mechanical Bowel Preparation in Elective Colorectal Surgery: A Meta-Analysis. *World Journal of Gastroenterology*, **24**, 519-536. <https://doi.org/10.3748/wjg.v24.i4.519>
- [5] Grewal, S., Reuvers, J.R.D., Abis, G.S.A., Otten, R.H.J., Kazemier, G., Stockmann, H.B.A.C., *et al.* (2021) Oral Antibiotic Prophylaxis Reduces Surgical Site Infection and Anastomotic Leakage in Patients Undergoing Colorectal Cancer Surgery. *Biomedicines*, **9**, Article 1184. <https://doi.org/10.3390/biomedicines9091184>
- [6] Rollins, K.E., Javanmard-Emamghissi, H., Acheson, A.G. and Lobo, D.N. (2019) The Role of Oral Antibiotic Preparation in Elective Colorectal Surgery. *Annals of Surgery*, **270**, 43-58. <https://doi.org/10.1097/sla.0000000000003145>

- [7] Migaly, J., Bafford, A.C., Francone, T.D., Gaertner, W.B., Eskicioglu, C., Bordeianou, L., Feingold, D.L., Steele, S.R. and Clinical Practice Guidelines Committee of the American Society of Colon and Rectal Surgeons (2019) The American Society of Colon and Rectal Surgeons Clinical Practice Guidelines for the Use of Bowel Preparation in Elective Colon and Rectal Surgery. *Diseases of the Colon and Rectum Journal*, **62**, 3-8.
- [8] Dou, R.X., Zhou, Z.L. and Wang, J.P. (2022) Bowel Preparation Protocol before Elective Surgery for Colorectal Cancer. *Chinese Journal of Gastrointestinal Surgery*, **25**, 645-647.
- [9] Zhang, H.S., Lu, L.S. and Zhao, C.X. (2019) Comparison of Efficacy between Elective Surgery after Stent Placement and Emergency Surgery in the Treatment of Obstructive Colorectal Cancer. *Chinese Journal of Practical Medicine*, **46**, 64-67.
- [10] Yang, W.Z., Cui, G.R., Wen, B.S., *et al.* (2019) Clinical Study of Ultra-Fine Endoscopy-Assisted Metal Stent Placement for the Treatment of Colorectal Cancer Complicated with Acute Intestinal Obstruction (with Video). *Chinese Journal of Digestive Endoscopy*, **36**, 133-135.
- [11] Zhang, H.Q., Zhang, G.J., Shan, Y.Z., *et al.* (2021) Comparison of Efficacy of Precise CT-Guided High or Low Ligation of the Inferior Mesenteric Artery in Laparoscopic Anterior Rectal Resection. *Chinese Journal of Postgraduates of Medicine*, **44**, 1010-1014.
- [12] Komen, N., Sliker, J., de Kort, P., de Wilt, J.H.W., van der Harst, E., Coene, P., *et al.* (2011) High Tie versus Low Tie in Rectal Surgery: Comparison of Anastomotic Perfusion. *International Journal of Colorectal Disease*, **26**, 1075-1078.
<https://doi.org/10.1007/s00384-011-1188-6>
- [13] Teng, W.H., Wei, C., Liu, W.J., *et al.* (2019) Preservation of the Left Colic Artery on Postoperative Anastomotic Leakage in Rectal Cancer Patients Receiving Neoadjuvant Therapy. *Chinese Journal of Gastrointestinal Surgery*, **22**, 566-572.
- [14] Liu, Y.J., Wang, G.C., Wan, X.B., *et al.* (2017) Efficacy of Pedicled Greater Omentum in Prevention of Postoperative Anastomotic Leakage after Surgery for Obstructive Colorectal Cancer. *Chinese Journal of General Surgery*, **32**, 23-25.
- [15] Li, X., Xu, Y.C., Wang, G.C., *et al.* (2021) Efficacy of Laparoscopic free Pedicled Greater Omentum in Prevention of Postoperative High-Risk Anastomotic Leakage in Colorectal Cancer. *Journal of Practical Medicine*, **37**, 361-364, 368.
- [16] He, Y.R., Zhu, Z.Q., Liu, S.J., *et al.* (2018) Reinforced Anastomotic Suturing for Prevention of Anastomotic Leakage after Laparoscopic Radical Resection of Rectal Cancer: A Prospective Randomized Controlled Trial. *Chinese Journal of Gastrointestinal Surgery*, **21**, 431-436.
- [17] Xu, L., Sun, X.Y., Xiao, Y., *et al.* (2023) Analysis of Anastomotic Leakage and Its Influencing Factors after Laparoscopic Anterior Resection for Rectal Cancer. *Chinese Journal of Digestive Surgery*, **22**, 742-747.
- [18] Li, J.J., Li, D.W., Yang, W., *et al.* (2020) Application Observation of Anastomotic Stents in Prevention of Anastomotic Leakage after Rectal Cancer Surgery. *Chinese Journal of Gastrointestinal Surgery*, **23**, 602-605.
- [19] Zhen, C.H., Zhu, J.F., Wu, R.D., *et al.* (2021) Controversies and Advances in Whether to Preserve the Left Colic Artery during Laparoscopic Radical Resection of Rectal Cancer. *Chinese Journal of Gastrointestinal Surgery*, **24**, 735-740.
- [20] Ioannidis, A. and Wexner, S.D. (2018) Role of Indocyanine Green Fluorescence Imaging in Preventing Anastomotic Leak in Colorectal Surgery: What Lies Ahead? *Diseases of the Colon & Rectum*, **61**, 1243-1244.

- <https://doi.org/10.1097/dcr.0000000000001163>
- [21] Su, H., Bao, M.D., Wang, P., *et al.* (2019) Application of Indocyanine Green Fluorescence Fusion Imaging Technology in Complete Laparoscopic Radical Resection of Right Colon Cancer. *Chinese Journal of Oncology*, **41**, 654-658.
- [22] Emile, S.H., Khan, S.M. and Wexner, S.D. (2022) Impact of Change in the Surgical Plan Based on Indocyanine Green Fluorescence Angiography on the Rates of Colorectal Anastomotic Leak: A Systematic Review and Meta-analysis. *Surgical Endoscopy*, **36**, 2245-2257. <https://doi.org/10.1007/s00464-021-08973-2>
- [23] Watanabe, J., Takemasa, I., Kotake, M., Noura, S., Kimura, K., Suwa, H., *et al.* (2023) Blood Perfusion Assessment by Indocyanine Green Fluorescence Imaging for Minimally Invasive Rectal Cancer Surgery (Essential Trial). *Annals of Surgery*, **278**, e688-e694. <https://doi.org/10.1097/sla.0000000000005907>
- [24] Alekseev, M., Rybakov, E., Shelygin, Y., Chernyshov, S. and Zarodnyuk, I. (2020) A Study Investigating the Perfusion of Colorectal Anastomoses Using Fluorescence Angiography: Results of the FLAG Randomized Trial. *Colorectal Disease*, **22**, 1147-1153. <https://doi.org/10.1111/codi.15037>
- [25] Ge, L., Zhou, H.T., Su, H., *et al.* (2021) Application of Indocyanine Green Fluorescence Imaging in Evaluating Intestinal Blood Perfusion during Complete Laparoscopic Left Hemi-Colectomy. *Chinese Journal of Surgery*, **59**, 338-342.
- [26] Cao, J., Bao, Y.D., Jiang, K.W., *et al.* (2020) Application Value of Indocyanine Green Fluorescence Imaging Technology in Laparoscopic Anterior Resection for Rectal Cancer. *Chinese Journal of General Surgery*, **35**, 764-767.
- [27] Lyu, Z.J., Liang, W.J., Wu, D.Q., *et al.* (2020) Analysis of Safety and Feasibility of Indocyanine Green Injection via Auxiliary Incision in Fluorescence Imaging-Based Laparoscopic Radical Resection of Right Colon Cancer. *Chinese Journal of Gastrointestinal Surgery*, **23**, 791-794.
- [28] Benčurik, V., Škrovina, M., Martínek, L., Bartoš, J., Macháčková, M., Dosoudil, M., *et al.* (2020) Intraoperative Fluorescence Angiography and Risk Factors of Anastomotic Leakage in Mini-Invasive Low Rectal Resections. *Surgical Endoscopy*, **35**, 5015-5023. <https://doi.org/10.1007/s00464-020-07982-x>
- [29] Bonadio, L., Iacuzzo, C., Cosola, D., Cipolat Mis, T., Giudici, F., Casagrande, B., *et al.* (2020) Indocyanine Green-Enhanced Fluorangiography (ICGF) in Laparoscopic Extraperitoneal Rectal Cancer Resection. *Updates in Surgery*, **72**, 477-482. <https://doi.org/10.1007/s13304-020-00725-6>
- [30] Jafari, M.D., Pigazzi, A., McLemore, E.C., Mutch, M.G., Haas, E., Rasheid, S.H., *et al.* (2021) Perfusion Assessment in Left-Sided/low Anterior Resection (PILLAR III): A Randomized, Controlled, Parallel, Multicenter Study Assessing Perfusion Outcomes with PINPOINT Near-Infrared Fluorescence Imaging in Low Anterior Resection. *Diseases of the Colon & Rectum*, **64**, 995-1002. <https://doi.org/10.1097/dcr.0000000000002007>
- [31] De Nardi, P., Elmore, U., Maggi, G., Maggiore, R., Boni, L., Cassinotti, E., *et al.* (2019) Intraoperative Angiography with Indocyanine Green to Assess Anastomosis Perfusion in Patients Undergoing Laparoscopic Colorectal Resection: Results of a Multi-center Randomized Controlled Trial. *Surgical Endoscopy*, **34**, 53-60. <https://doi.org/10.1007/s00464-019-06730-0>
- [32] Huang, H.B., Luo, S.K., Zhang, K., *et al.* (2018) Clinical Study on Indwelling Anal Canal for Preventing Anastomotic Leakage after Rectal Cancer Surgery. *Chinese Journal of General Surgery*, **33**, 38-40.
- [33] Choy, K.T., Yang, T.W.W., Heriot, A., Warriar, S.K. and Kong, J.C. (2021) Does Rec-

- tal Tube/Transanal Stent Placement after an Anterior Resection for Rectal Cancer Reduce Anastomotic Leak? A Systematic Review and Meta-analysis. *International Journal of Colorectal Disease*, **36**, 1123-1132. <https://doi.org/10.1007/s00384-021-03851-8>
- [34] Zhang, C.R., Xu, S.Y., Lyu, Y.C., *et al.* (2023) Anal Canal Drainage for Preventing anastomotic Leakage after Laparoscopic Anterior Resection for Rectal Cancer: A Meta-Analysis. *Chinese Journal of Gastrointestinal Surgery*, **26**, 689-696.
- [35] Sun, S.W., Zheng, X.Y., Yu, J.T., *et al.* (2024) Application of Double Anal Canal Drainage in Preventing Anastomotic Leakage after Laparoscopic Anterior Resection for Rectal Cancer. *Chinese Journal of Gastrointestinal Surgery*, **27**, 627-629.
- [36] Stoma Professional Committee of Anorectal Physicians Branch of Chinese Medical Doctor Association, Anorectal Physicians Branch of Chinese Medical Doctor Association, Colorectal Surgery Group of Surgical Society of Chinese Medical Association, *et al.* (2022) Chinese Expert Consensus on Preventive Intestinal Stoma in Surgery for middle and Low Rectal Cancer (2022 Version). *Chinese Journal of Gastrointestinal Surgery*, **25**, 471-478.
- [37] Li, Y.H., Lin, G.L., Li, C.L., *et al.* (2021) The Effect of Neoadjuvant Radiotherapy and Preventive Stoma on the Incidence of Anastomotic Leakage after Radical Resection for Middle and Low Rectal Cancer. *Chinese Journal of Gastrointestinal Surgery*, **24**, 498-504.
- [38] Ye, Y.J. and Jiang, H.P. (2018) Systematic Review of the Effect of Preventive Stoma, Preoperative Radiotherapy, and Inferior Mesenteric Artery Ligation Level on the Incidence of Anastomotic Leakage after Rectal Cancer Surgery. *Chinese Journal of Gastrointestinal Surgery*, **21**, 448-455.
- [39] Lee, B.C., Lim, S., Lee, J.L., Kim, C.W., Yoon, Y.S., Park, I.J., *et al.* (2020) Defunctioning Protective Stoma Can Reduce the Rate of Anastomotic Leakage after Low Anterior Resection in Rectal Cancer Patients. *Annals of Coloproctology*, **36**, 192-197. <https://doi.org/10.3393/ac.2019.11.19.1>
- [40] Degiuli, M., Elmore, U., De Luca, R., De Nardi, P., Tomatis, M., Biondi, A., *et al.* (2021) Risk Factors for Anastomotic Leakage after Anterior Resection for Rectal Cancer (RALAR Study): A Nationwide Retrospective Study of the Italian Society of Surgical Oncology Colorectal Cancer Network Collaborative Group. *Colorectal Disease*, **24**, 264-276. <https://doi.org/10.1111/codi.15997>