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REVIEW ARTICLE

The application of defunctioning stomas after low anterior resection of rectal cancer

Hongwei Yao[1] · Yongbo An[1] · Zhongtao Zhang[1]

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Abstract

Defunctioning stomas are frequently used by colorectal surgeons after unsatisfactory anastomosis. The primary purpose of constructing a defunctioning stoma is to prevent an anastomotic leakage or to alleviate the detrimental consequences of it. However, the construction of defunctioning stomas is not free and is associated with adverse impacts on the patient. Stoma-related complications can develop in different stages and can impair a patient's quality of life. Furthermore, one in every four to six defunctioning stomas turns into a non-closure stoma. Since no definite indications for the creation of a defunctioning stoma are available, surgeons have to carefully weigh their benefits against their adverse effects. Thus, the precise selection of patients who should undergo the creation of a defunctioning stoma is of great importance, and an alternative method for preventing anastomotic leakage is needed.

Keywords Defunctioning stoma · Low anterior resection · Rectal cancer · Anastomotic leakage

Introduction

Colorectal surgeons have long devoted themselves to provide optimal treatment based on oncological and functional considerations. Low anterior resection (LAR) or ultralow anterior resection (ULAR), which is performed with the intention of preserving the anorectal function of patients with rectal cancers, serve as the first-line options for surgeons. Patients who undergo this procedure have a high chance of avoiding permanent stomas; however, they might instead risk a feared postoperative complication—anastomotic leakage.

The first definition and grading system of anastomotic leakage (AL) after anterior resection was established in 2010 by the International Study Group of Rectal Cancer (ISREC) [1]. The incidence of AL according to this definition was reported to be 7.5–15.9% [2–4]. AL is both a short-term and long-term outcome [5, 6]. Although many previous studies have been devoted to identifying the risk factors for AL [5, 7–9] and exploring ways to prevent AL [10–12], the incidence of this complication remains unchanged [13, 14].

Among the various methods of preventing AL, defunctioning stoma construction has been considered to be effective and has been frequently applied. Multicenter cohort studies have shown defunctioning stomas were created in 32.3–42.1% of patients who underwent low anterior resection [4, 15, 16], while a large sample study showed that the rate was 15.89% in patients who underwent open anterior resection of rectal cancer and 1.17% in patients who underwent laparoscopic anterior resection [5]. In some studies, more patients received ileostomy (64–98%) than colostomy (2–36%) [4, 16]. In other studies, colostomy was performed more frequently (61.9–70.2%) [5]. Both methods provided a satisfactory degree of protection for the site of anastomosis [5, 17]; however, there was no conclusion on the method that was associated with more stoma-related complications [17–20].

The rate at which defunctioning stomas are applied in LAR is not low, and the rate at which they are in specific procedures such as transanal total mesorectal excision is extremely high [21]; thus, a review is desperately needed to discuss the positive and negative effects of the construction

Hongwei Yao and Yongbo An contributed equally to this article as co-first authors.

✉ Zhongtao Zhang
zhangzht@ccmu.edu.cn

[1] Department of General Surgery, Beijing Friendship Hospital, National Clinical Research Centre of Digestive Diseases, Capital Medical University, 95 Yong'an Road, Xi-Cheng District, Beijing 100050, China

of defunctioning stomas to help us make better decisions regarding the application of this procedure.

Materials and methods

We performed a systematic literature search of the MEDLINE, EMBASE and Cochrane Library database. The search was restricted to the English literature. There was no restriction on search period. Various combinations of the following headings were applied during the search: rectal neoplasms (MeSH term), defunctioning stoma, protective stoma, diverting stoma, covering stoma, ileostomy and colostomy. The references of the identified studies were also screened to identify additional studies.

The indications for defunctioning stomas

In most cases, the decision to construct a defunctioning stoma depended on the individual surgeon's experience. The indications for defunctioning stomas were therefore a practical problem for all surgeons. A Japanese retrospective study enrolling 1014 patients reported that male sex, larger tumor size, more advanced tumor depth (T3/T4 stage), lymph node positivity, neoadjuvant (chemo) radiotherapy, low tumor location, low anastomotic level, massive intraoperative bleeding, high ligation of inferior mesenteric artery (IMA), lateral lymph node dissection, open surgery, incompleteness of the anastomotic ring and a positive leakage test were associated with defunctioning stoma construction [4]. In other words, these clinical factors should be regarded as indications for defunctioning stoma construction in this center. In the Polish consensus statement on the defunctioning stoma, the indications for stoma construction included: low anastomosis (< 3 cm from the anal pectin), neoadjuvant therapy, immunosuppression, positive result of anastomosis tightness test and/or incomplete stapler rings, BMI < 19 kg/m^2, ASA III/IV and significant intraoperative difficulties (narrow pelvis, technical difficulties) [22]. In a survey of the members of the American Society of Colon and Rectal Surgeons (ASCRS), pelvic irradiation, low albumin/poor nutritional status and steroid/immunosuppressant use were regarded as the most important factors affecting their decision to apply a defunctioning stoma after a "satisfactory" mid-to-high colorectal anastomosis [23]. Overall, the indications for the application of a defunctioning stoma displayed a degree of overlap, despite the geographic difference. A prospective cohort study was needed to testify the effectiveness and feasibility of the indications for the application of defunctioning stoma.

Positive effects of defunctioning stomas

The primary purpose of applying a defunctioning stoma is to divert the bowel contents from passing through an unsafe anastomotic site and therefore prevent anastomotic leakage. The results of meta-analyses [24, 25] of randomized controlled trials (RCTs) showed that a defunctioning stoma can reduce both the incidence of AL and the rate of reoperation to treat AL after low anterior resection for rectal cancer. A meta-analysis of nonrandomized studies showed that although a defunctioning stoma did not reduce the incidence of AL, it might mitigate the consequences of AL [25]. Considering the potential selection bias in nonrandomized controlled studies—that is, patients with higher risk of developing AL have a greater possibility of receiving a defunctioning stoma—the results of the meta-analysis of nonrandomized studies seemed to be reasonable. Although the two above-mentioned meta-analyses revealed that defunctioning stoma construction significantly reduced the incidence of AL, there were limitations in that the numbers of RCTs enrolled in these two studies were small and the populations that were analyzed in these two meta-analyses mainly came from the RCTs of Matthiessen et al. [26] and Chude et al. [27]. Thus, more powerful evidence is needed to shed light upon the issue.

A large sample multicenter prospective observational study using propensity score matching (PSM) showed that defunctioning stoma application did not reduce the rate of symptomatic AL (grade B and grade C according to the ISREC grading methods [1]), but that it did reduce the rate of AL requiring urgent reoperation [4]. The study illustrated some concerns toward the limitations of previous RCTs and the difficulties of conducting further RCTs. Instead, using PSM we might obtain some powerful evidence, especially when RCTs are difficult to design and conduct.

More recently, a well-designed multicenter open-label RCT again reported that the construction of a defunctioning stoma had a positive role in preventing the occurrence of AL [28]. Although the study was closed early before the planned sample size was reached, the result had already shown that the incidence of AL in patients without a defunctioning stoma was significantly higher than that in patients with one. Furthermore, the authors of the study took into account the possibly protective effect of a J-pouch on the occurrence of AL, and showed that in the subgroup of patients who received J-pouch reconstruction, defunctioning stoma construction still reduced the incidence of AL, which further demonstrated the protective effect of defunctioning stoma construction against AL. Another recent multicenter RCT showed that patients who were randomized into a defunctioning stoma group had a

lower incidence of AL than patients who were randomized into a non-defunctioning stoma group [29]. However, the authors of the study pointed out that the protective effect of a defunctioning stoma against AL was accompanied by increased cost.

Other large sample retrospective studies also showed that defunctioning stoma construction reduced the incidence of AL [30] or at least reduced the incidence of AL requiring reoperation [16]. Furthermore, the data from the American College of Surgeons-National Surgical Quality Improvement Project (ACS- NSQIP) revealed that receiving a defunctioning stoma reduced the incidence of sepsis, septic shock and the need for reoperation in patients with colo-anal anastomosis [31]. Due to the retrospective nature of these studies, the indications for creating defunctioning stomas, which were not clearly mentioned in these articles, were difficult to track. We tend to believe that in most cases, the decision to create a performing defunctioning stoma was made by the surgeon before or during the operations.

In summary, most of the powerful evidence supported that application of defunctioning stomas had positive effects in the prevention of AL and the mitigation of the consequences of AL. Defunctioning stoma construction should be recommended for patients with a high risk of developing AL. Table 1 shows the reviewed original studies that compared the incidence of AL in patients with and without defunctioning stomas.

Adverse effects of defunctioning stoma application

Although the creation of a defunctioning stoma may have positive effects with regard to the prevention of AL, it is not rational to make a defunctioning stoma for every patient undergoing LAR. It is necessary for surgeons to realize that defunctioning stomas are associated with significant adverse effects. In some retrospective studies, defunctioning stoma-related complications were classified into several categories according to the time period in which they occurred and then analyzed [32, 33]. In one study, the overall incidence of defunctioning stoma-related complications in patients who underwent LAR was reported to be as high as 53.8% [34]. Thus, increased attention should be paid to patients with unpleasant stoma experiences.

Stoma-related complications after primary surgery with stoma construction

Obstructive complications were considered to be serious and were not rare after defunctioning stoma creation in patients undergoing laparoscopic surgery. A retrospective study of 161 patients undergoing laparoscopic colorectal surgery with defunctioning ileostomy reported that eight patients (5%) developed obstructive complications after stoma creation [35]. Re-laparotomy was the most common solution for these patients; however, the authors proposed an algorithm stressing the potentially positive role of endoscopic and laparoscopic management for obstructive complications. Another study reported a similar incidence of obstructive complications related to ileostomy after laparoscopic rectal cancer surgery (5%) and all of these patients required acute surgical intervention [34]. Other complications after stoma creation included parastomal abscess/infection, stoma retraction, stoma malfunction, hemorrhage and stenosis [33, 34, 36]; the incidence of these complications was relatively low. It was shown that the rates of parastomal abscess and stoma retraction after loop colostomy construction were higher than after loop ileostomy construction [36]. Few

Table 1 Studies analyzing the effect of defunctioning stomas on anastomotic leakage

Study [4, 16, 26–30]	Design	*N*	Indication for DS	Incidence of AL	
				Patients with defunctioning stoma	Patients without defunctioning stoma
Matthiessen et al.	RCT	234	–	10.3%* (12/116)	28.0% (33/118)
Chude et al.	RCT	256	–	2.2%* (3/136)	10% (12/120)
Shiomi et al.	Multicenter prospective cohort study	330 (1014)[a]	Surgeon's decision	10.9% (18/165)	15.8% (26/165)
Mrak et al.	RCT	166	–	5.8%* (5/86)	16.3% (13/80)
Floodeen et al.	RCT	234	–	10.3%* (12/116)	28.0% (33/118)
Rutegard et al.	Retrospective cohort study	487	Not mentioned	11.1%* (50/451)	33.3 (12/36)
GastingerI et al.	Multicenter prospective study	2729	Surgeon's decision	14.2% (262/1848)	14.5% (128/881)

AL anastomotic leakage, *RCT* randomized controlled trial

[a]1014 patients before propensity score matching; 330 patients after propensity score matching

*Indicates a statistically significant difference in the incidence of AL between patients with defunctioning stomas and those without ($P < 0.05$)

studies have concentrated on the management of these rare complications.

Stoma-related complications of the stoma status

Patients with defunctioning stoma after LAR for rectal cancer may suffer from various complications during the stoma-carrying period. Dehydration induced by a high-output stoma was a common complication that affected 2.6–29% of patients after ileostomy [18, 32, 34, 36–38]. A large sample retrospective study by Messaris et al. also showed that dehydration was the most common reason for readmission after ileostomy (44/603). However, as high as the dehydration rate was, Messaris et al. pointed out that this complication was preventable; the effective preventive management included identifying patients at risk beforehand, implementing enterostomal therapy consultation, using intake and output diaries for patients to achieve a fluid balance and careful medication use (avoidance of diuretics) [39]. Along with dehydration, acute kidney injury (AKI) is another complication following high-output stoma creation; the incidence was reported to be 7% in studies by Kye et al. [40] and Phatak et al. [32]. Kye et al. also demonstrated that the patient's nutritional status was affected by stoma-related complications; thus, the nutritional support of these patients should be refined. Villafranca et al. developed a three-stage protocol to treat patients with high-output stomas [41]. The protocol included diet instruction, medication and a monitoring strategy, and was reported to be effective in the early detection and management of electrolyte abnormalities in these patients.

Skin irritation was reported to be one of the most frequent problems for patients carrying a defunctioning stoma. It occurred in 3.6–24.5% of patients with a defunctioning stoma and usually treated conservatively [18, 34, 36, 37]. In cases with a permanent stoma, the incidence of stoma-related skin disorders was as high as 73%, Lyon et al. analyzed the spectrum of the skin disorders [42]. In rare cases, patients also developed chronic papillomatous dermatitis due to the reaction to mechanical and chemical irritation [43]. Stoma prolapse was a complication after defunctioning stoma construction that could impair a patient's quality of life [44], and some patients with prolapse required surgical intervention [36]. A meta-analysis showed that patients after colostomy had a higher incidence of developing stoma prolapse than patients after ileostomy [20]; however, a large-size RCT is needed to verify this conclusion. Parastomal hernia was another complication that could occur during the stoma period, and reoperation was needed when a parastomal hernia caused a proximal obstruction. Other complications included obstruction, gastrointestinal bleeding and stoma stenosis, and in most cases these complications could be treated conservatively [38].

Stoma-related complications after stoma reversal

The most direct impact of defunctioning stoma creation is that the patient has to undergo additional stoma reversal surgery, which is sometimes accompanied by postoperative complications. Furthermore, some complications after stoma reversal are severe and may necessitate a series of treatments. The data from the NSQIP database showed that the rates of major complications, minor complications and death after stoma closure were 9.3%, 8.4% and 0.6%, respectively [45]. The study identified several independent predictors of major complications after stoma closure—most were related to the patient's general condition and comorbidities. A systemic review of 48 studies including 6107 cases by Chow et al. showed that the morbidity rate after ileostomy closure was 17.3%; small bowel obstruction (7.2%) and wound sepsis (5.0%) were the most common complications. One-third of the patients with bowel obstruction required re-laparotomy [46]. In terms of wound infection, Liang et al. reviewed 126 patients who underwent ileostomy or colostomy reversal and reported that 48 patients (36.0%) had surgical site infection (SSI) after stoma reversal. Fascial dehiscence, colostomy, thicker subcutaneous fat and black race were shown to be independent risk factors for SSI after stoma reversal [47]. Purse-string closure following stoma reversal was considered to be an effective way to lower the rate of infection and also had a better cosmetic outcome [48, 49].

The incidence of incisional hernia (IH) was shown to be 1.8% in Chow's review and 7% in Bhangu's review [50], while observational studies that were specifically designed to evaluate IH after stoma closure reported that the rate of IH was as high as 11.7–34% [50–53]. These observational studies applied computed tomography (CT) and ultrasound (US) to detect hernia, which might explain the huge difference in the rate of IH in these observational studies in comparison to the reviews. However, in some studies, only the incidence of clinical hernia (hernia diagnosed without the help of CT and US) rate was analyzed; it was reported to be 11.9–14% [50, 53], which was still higher than the rate shown in the reviews. The reoperation rate among patients with IH was reported to be 51% in Bhangu's review, which meant that this group of patients had to undergo at least three operations during the entire course of treatment for rectal cancer. Studies on risk factors for IH and the prevention of IH after stoma closure were lacking. A higher body mass index (BMI) and preoperative blood pressure were found to be the risk factors for the development of IH [52, 53].

Complications related to the closure site after stoma reversal include anastomotic leakage and anastomotic stricture [36, 37, 46, 54]. These complications were rare (0.8–1.4%); however, the development of closure site leakage might be associated with delays in stoma closure [55].

The quality of life of defunctioning stoma recipients

The primary reason why both the surgeon and the patient tended to avoid stoma construction was that they believed that the procedure would impair the patient's quality of life. However, the evidence that supports this concept was actually not adequate and the evaluation of the quality of life (QOL) of patients with defunctioning stoma after rectal cancer surgery might not be well reflected by questionnaires alone.

Two studies compared the QOL of patients who underwent LAR with temporary ileostomy to the QOL of patients who underwent high anterior resection (HAR) and showed that the QOL of the former group was lower than that of the latter group in some aspects (i.e., the physical function and role function scores) [56, 57]. Other studies analyzed only one group of patients and compared the QOL before and after stoma application in these patients. For patients with a defunctioning stoma, the global quality of life (GL) score was reported to remain unchanged throughout the evaluation period [58, 59] or improve after stoma closure [57, 60]. These results gave us an illusion that the application of defunctioning stoma did not affect patient QOL. However, Neuman et al. identified several stoma-related difficulties using the stoma quality of life (SQOL) questionnaire, despite patients having a good GL score, which led them to conduct a further study to find the cause of this contradiction [58]. In their subsequent study, Neuman et al. conducted in-depth qualitative interviews with patients with defunctioning stoma after rectal cancer surgery and found that the undetected reduction of the QOL score was affected by their cancer experience, which had a more substantial influence on their life. "Response shift", "recalibration of patients' standards for measuring QOL" and "reconceptualization of what good QOL is" were the refined phrases Neuman et al. used to explain their results [61]. In conclusion, although the questionnaires are designed to measure a patient's QOL, the quantitative data results would still unavoidably cover some facts. Quality of life, after all, is a multidimensional variable that is difficult to measure.

Other possible adverse effects of defunctioning stoma application

The anorectal function might be influenced by defunctioning stoma application. In a 12-year follow-up study by Gadan et al. [62], incontinence in relation to flatus and liquid stools was reported to be more common in patients who were originally randomized into a defunctioning stoma group than in patients who were randomized into a non-defunctioning stoma group. The authors hypothesized that the anorectal function impairment induced after defunctioning stoma application possibly included a reduced external anal sphincter volume and maximally tolerated volume [63, 64], a higher rate of diversion colitis [65] and the altered bacterial microflora [66]. Further studies should focus on the effect that the duration of carrying a defunctioning stoma has on the anorectal function.

Defunctioning stoma application also affected the administration of postoperative adjuvant therapy and the medical cost. It was reported that in some cases the application of adjuvant chemotherapy was delayed [32, 67] and in some cases the undergoing adjuvant chemotherapy was omitted [38] due to the construction of a defunctioning stoma and/or the complications related to the defunctioning stoma. Defunctioning stoma application resulted in an increased average total cost for patients after low anterior resection for cancer [29], and in Koperna's study it was shown to be one of the most important cost drivers for patients after LAR for rectal cancer [68].

The adverse effects associated with defunctioning stomas are summarized in Table 2.

Decision on stoma reversal

Not all patients with defunctioning stomas had the opportunity to receive stoma reversal operations. According to previous studies, one in every four to six "temporary" stoma was not reversed [69–73], and the rate of stoma reversal was even lower in elderly patients (age ≥ 66 years) after LAR with defunctioning stoma construction [74]. Several studies focused on the factors limiting stoma reversal, and the results of a meta-analysis by Zhou et al. showed that patient characteristics (age ≥ 65 years, ASA score > 2, comorbidities, stage IV tumor), surgical factors (open surgery, surgical complications, anastomotic leakage) and oncological outcomes (local recurrence) were all related to the non-closure of defunctioning stomas [72]. Furthermore, a study based on a national database identified socioeconomic deprivation as a risk factor for defunctioning stoma non-closure; the explanation to this may be: (1) patients from more socioeconomically deprived areas tend to have poorer health conditions; (2) these patients did not have easy access to follow-up treatment after primary surgery [71]. Facing the fact that a substantial proportion of patients with defunctioning stomas will develop permanent stomas and that several uncontrollable factors will increase the non-closure rate, patients who are going to receive defunctioning stoma construction must be well informed before surgery of the high rate of patients who end up receiving permanent stomas instead. Surgeons should keep in mind that, as den Dulk et al. suggested in their work [69], "temporary stomas should be created as if they are permanent stomas." Furthermore, the attempt to extend the indication of stoma reversal was of value: stoma closure for patients with persistent asymptomatic

Table 2 The adverse effects of defunctioning stoma creation

The adverse effects of defunctioning stoma application	Stoma-related complications	Complications of stoma creation	Obstructive complications [34, 35]; parastomal abscess/infection [33]; stoma retraction [34]; stoma malfunction [33]; hemorrhage [36]; stenosis [36]
		Complications of stoma status	Dehydration [18, 32, 34, 36–38]; AKI [32, 40]; nutritional problem [40]; skin irritation [18, 34, 36, 37]; stoma prolapse [36, 44]; parastomal hernia [33]; obstruction [38]; gastrointestinal bleeding [38]; stoma stenosis [38]
		Complications of stoma reversal	Small bowel obstruction [46]; wound infection [46, 48, 49]; IH [46, 50–53]; anastomotic leakage [36, 46]; anastomotic stricture [37]
	Impaired QOL		Impaired stoma quality of life scale [58, 61]
	Other adverse effects		Impaired anorectal function [63]; the effect on adjuvant chemotherapy [32, 38]; increased economic burden [29]

AKI acute kidney injury, *IH* incisional hernia, *QOL* quality of life

anastomotic leakage was reported to be feasible in some cases [75].

The timing of stoma reversal was another issue that concerned surgeons and patients. Generally, defunctioning stomas were closed 6–12 weeks after the primary surgery. This waiting period before closure was not a pleasant time, as patients might suffer from various complications that were summarized in this review. Furthermore, the waiting period might be prolonged due to some postoperative complications, such as chronic AL and/or adjuvant chemotherapy. Thus, some studies explored the feasibility of early stoma reversal (7–13 days after primary surgery) [76, 77], and later the RCTs showed that early reversal might be superior in terms of the difficulty of reversal surgery, rate of postoperative complications and medical cost [78–80]. Regarding the association between the timing of reversal and chemotherapy, it was shown that closing a defunctioning stoma during adjuvant chemotherapy was safe [55, 81], and the complication rate of patients who received stoma reversal after the third adjuvant chemotherapy cycle was similar to that of patients who received stoma reversal after the sixth adjuvant chemotherapy cycle [81].

Conclusion

Defunctioning stoma construction after LAR of rectal cancer was an effective way to prevent anastomotic leakage and to alleviate its consequences. Explicit indications for defunctioning stoma construction are needed to help select suitable recipients, because defunctioning stoma application is not free and is associated with adverse effects. Moreover, because complications exist in each period, the patients' QOL will also be impaired. Furthermore, it cannot be guaranteed that a defunctioning stoma will be temporary, as one in every four to six defunctioning stomas turns into a non-closure stoma.

The exploration of substitutes for defunctioning stomas should be encouraged in the future. "Spontaneously closing cannula ileostomy" reported by Hua et al. [82] and ghost ileostomy [83] are both promising alternative approaches that are trying to achieve a similar preventive effect against AL and to simultaneously avoid the traditional problems associated with stomas. However, the precise selection of defunctioning stoma recipients remains the most essential part of a surgeon's work in reducing the adverse effects of defunctioning stomas.

Compliance with ethical standards

Conflict of interest The authors declare no conflicts of interest in association with the present study.

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