

# Effect of Placing Double-lumen Irrigation-suction Tube on Spontaneous Closure of Anastomotic Leakage Following Rectal Cancer Surgery

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## Research Article

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# Abstract

**Purpose:** This study aimed to explore the effect of placement of double-lumen irrigation-suction tubes (DLIST) on the spontaneous closure of anastomotic leakages (AL) after rectal cancer surgery.

**Methods:** The study was performed at two centers which was managed by the same chief. The treatment in the two center were same. From January 2011 to June 2020, patients with postoperative AL after rectal cancer surgery were eligible. Patients were divided into a passive drainage (PD) group and a DLIST group according to whether the PD,placed during the rectal cancer surgery, had been replaced with the DLIST. The effect of DLIST on the AL was evaluated.

**Result:** There were 76 patients in the DLIST group and 52 in the PD group. The DLIST group was more inclined to achieve spontaneous closure of AL (HR =3.048; 95% CI: 1.787-5.197; P<0.001). Both length of stay and costs of the treatment in the DLIST group were lower (54 [41.25-117] days vs. 112 [66.75-127.75] days,  $P=0.005$ ; and \$18,721 [\$14,982-44,960] vs. \$40,840 [\$20,932-50,529],  $P< 0.001$ ).

**Conclusion:** Placement of DLIST is an effective method for treating AL following rectal cancer surgery. Compared with PD, the cost of DLIST in the treatment of AL is lower and the length of stay is shorter.

## 1. Introduction

Anastomotic leakage (AL) is one of the most severe complications after rectal cancer surgery[1]. The incidence of rectal AL ranges from 5–28%[2-6]. The spontaneous closure rate varied in different studies[7-10].

More than half of the patients end up with a permanent stoma after the standard treatment[7, 8]. In the past 10 years, two novel methods for the treatment of AL have been proposed[9, 10]. In few selected patients, the two methods,transanal drainage and endoscopic vacuum-assisted closure, elevated the spontaneous closure rate as high as 90%[9,10]. However, in a recent study involving more patients, it was shown that the 2-year spontaneous closure rate using the two new methods was only about 50%[11]. In short, treatment aimed at spontaneous closure of rectal AL is still relatively difficult and worthy of exploration.

A double-lumen irrigation-suction tube (DLSIT) was introduced in our previous studies[12,13]. It has been proven that DLIST is more superior for source control compared with passive drainage. Our recent multicenter research showed that placing DLISTs during rectal surgery might promote the spontaneous closure of AL[12]. However, in clinical work, it was discovered that intraoperative placement of an active drainage device similar to a DLIST was rare. When AL occurred, effective irrigation and drainage were not established, and there was often a pus cavity around the passive drainage tube. The two centers involved in this study treated a large number of rectal AL patients every year. In recent years, our center tried to replace the passive drainage tube with DLIST in patients with rectal AL after admission to our centers. In

the present study, we explored the effect of replacement of PDs with DLISTs on the spontaneous closure and provide a benchmark for future treatment.

## **2. Method And Material**

This was a retrospective cohort study performed at two tertiary hospitals. Every year, hundreds of patients with refractory intestinal fistula transferred to the two centers, which was managed by the same chief. The treatment in the two center were same. The ethics committee of Jinling Hospital and Jiangning hospital approved the retrospective data collection; all subjects provided signed informed consent. All methods were carried out in accordance with relevant guidelines and regulations.

DLIST was introduced in our previous study[13]. In brief, the DLIST consists of an irrigation catheter, a suction catheter, and an end-closed supporting pipe (made by a 24 Fr silica gel drainage tube). Saline was continuously irrigated through the irrigation catheter at 100–150 mL/h, along with drainage from the suction catheter under continuous negative pressure of 150-200 mmbar (Figure 1).

### **2.1. Study design**

From January 2011 to June 2020, patients who transferred to either of the two centers with postoperative AL after rectal cancer surgery were eligible. The exclusion criteria included 1) patients with evidence of tumor metastasis and 2) patients receiving an emergency surgery due to the AL after admission.

According to whether or not the passive drainage placed during the rectal cancer surgery was replaced with the DLIST, patients were divided into a passive drainage (PD) group and a double-lumen irrigation-suction tube (DLIST) group (Figure 2). The effect of DLIST on the AL was evaluated.

### **2.2. Follow up**

Patients were planed to received a definitive surgery at least after three months after infection control and improvement of nutritional status. During the period before definitive surgery, there were patients with spontaneous closure. All the patients were followed up to spontaneous closure or to discharge after definitive surgery. The primary outcome was the spontaneous closure of AL. The secondary outcomes included the hospital length of stay (LOS) and hospitalization expenses.

Spontaneous closure was confirmed only after colonography, and the duration from admission to spontaneous closure was recorded. In our study, colonography would be arranged only after the flushing or drainage fluid was clear for several days.

### **2.3. Replacement of PD with DLIST**

After admission, patients were treated with cefoperazone, and CT and colonography were performed. During imaging examinations, the length of the pus cavity and the position of the drainage tube were confirmed. In our study, immediate emergency surgery would be considered only if abdominal diffuse feces existed. Except for emergency surgery, the treatment process was as shown in Figure 2. In general,

if the patient was asymptomatic (after using antibiotics, no systemic inflammatory response syndrome[SIRS]) after admission, replacement with DLIST would not be considered whether or not there was an isolated pus cavity or a pus cavity that could be contacted by the drainage tube. For patients with symptoms (with SIRS), there were three treatment courses. 1) If there was a pus cavity that could be reached by a drainage tube and there was no isolated pus cavity, replacement with DLIST was performed. 2) If there was not only a pus cavity that could be reached by a drainage tube but also an isolated pus cavity, replacement with DLIST was the first choice; if SIRS was still present within 48 h after the PD was replaced, a CT-guided puncture for isolated pus cavity the was planned. 3) If there was only an isolated pus cavity, replacement with DLIST was not performed, and instead a CT-guided puncture was performed. Antibiotics were stopped 5 days after the patient became asymptomatic.

Before the placement of DLIST, the shape of the drainage tube was evaluated by CT and sinography. During the process, the patient lay supine. After iodophor disinfection. A guide wire was insert in the abdomen via PD tube. PD was removed while the guide wire was in place. Seldinger method was used in the subsequent process. Use a skin expander to enlarge the sinus to the desired size then DLIST was inserted under the guidance of guide wire. A CT scan was then performed to confirm the position of the DLIST.

## 2.4. Data analyses

All statistical analyses were performed using SPSS 26.0 (IBM, Analytics, Armonk, NY). Mann-Whitney U tests were used to compare continuous variables across groups. Fisher exact tests were used to compare categorical variables. Kaplan-Meier estimates followed by a log-rank test and multivariate Cox regression analysis were used to compare the effects of different methods. A *P* value of <0.05 was considered to indicate statistical significance.

## 3. Results

### 3.1. Population

From January 2011 to June 2020, a total of 153 patients with postoperative AL after rectal cancer surgery were transferred to our centers. Of these, eight patients with tumor metastasis during the treatment and 17 patients receiving emergency surgery immediately after admission were excluded from the study; thus, 128 patients were enrolled in our study (Figure 2).

The characteristics of the 128 patients are shown in Table 1. Of these, 76 patients underwent replacement of PD with DLIST and formed the DLIST group. The interval from admission to replacement was three days (Interquartile range [IQR]: 2-5 days). Another 52 patients did not have replacement of PD and formed the PD group. There were 38 (29.69%) females, 23 in DLIST group (30.26%) and 15 in PD group (28.85%) (*P* = 0.863). The median age was 64years (IQR: 58-66 years) in the DLIST group and 59 years (IQR: 54-68 years) in the PD group (*P*=0.242). The interval from cancer surgery to AL diagnosis was eight days (IQR: 7-9 days) in the DLIST group and eight days (IQR: 7-8 days) in the PD group (*P* = 0.394).

Table 1  
patients characteristics

Clinical variables	PD group (n=52)	DLIST group (n=76)	p
Female,No. (%)	15(28.85)	23(30.26)	0.863
Age, years;(median,IQR )	59(54-68)	64(58-66)	0.242
BMI, kg/m <sup>2</sup> ,(median,IQR )	21.2(21-24.2)	21.55(20-22.47)	0.589
Tumor stage,No. (%)			0.140
I	3(5.76)	3(3.95)	
IIA	16(30.77)	12(15.79)	
IIB	11(21.15)	12(15.79)	
IIC	16(30.77)	31(40.79)	
IIIA	4(7.69)	10(13.16)	
IIIB	1(1.92)	4(5.26)	
IIIC	1(1.92)	4(5.26)	
Perioperative radiotherapy,No. (%)	2(3.85)	2(2.63)	1.000
Neoadjuvant therapy,No. (%)	4(7.69)	9(11.84)	0.445
Dissected lymph nodes number<12,No. (%)	3(5.76)	3(3.95)	0.686
Laparoscopic cancer surgery,No. (%)	41(78.85)	60(78.95)	1.000
Interval from cancer surgery to AL diagnosed, day, (median,IQR )	8(7-8)	8(7-9)	0.394
Interval from AL diagnosed to admission, day, (median,IQR )	28.5(21-36.75)	20(18-25)	<0.001
Length from anastomosis to anus ,cm, (means±SD)	6.34±3.91	7.49±3.99	0.108
High ligation of the inferior mesenteric artery ,No. (%)	48(92.31)	70(92.10)	1.000
Ileostomy, No. (%)	41(78.85)	8(10.53)	<0.001
Puncture after admission, No. (%)	29(38.16)	27(51.92)	0.123
Length of pus cavity>5cm, No. (%)	8(15.38)	48(63.16)	<0.001
Hemoglobin, g/L, (median,IQR )	114(109-123)	109(100-117)	0.002
WBC*10 <sup>9</sup> /L, (median,IQR )	8.1(6.92-13.57)	16(9.25-19)	<0.001

Clinical variables	PD group (n=52)	DLIST group (n=76)	p
Platelet*10 <sup>9</sup> /L, (median,IQR )	298(209-341)	321(198-485.25)	0.543
CRP, mg/L, (means±SD)	49.63±43.23	105.82±52.17	<0.001
PCT, ug/L, (means±SD)	2.05±2.9	4.66±3.08	<0.001
Alb, g/L, (median,IQR)	31(28-36)	28(26-32)	<0.001
Kidney injury,No. (%)	1(1.92)	1(1.31)	1.000
Hepatic injury,No. (%)	7(13.46)	21(27.63)	0.081
Respiratory function injury,No. (%)	1(1.92)	3(3.95)	0.639
cirrhosis,No. (%)	2(3.85)	3(3.95)	0.977
Diabetes mellitus,No. (%)	8(15.38)	8(10.53)	0.414
Smoking,No. (%)	13(25)	15(19.73)	0.479
Interval from admission to replacement with AD, days, (median,IQR )	—	3(2-5)	—

The interval from cancer surgery to diagnosis of AL was > 30 days for six patients, five of whom (2 PD, 3 DLIST) had protective end ileostomy closure during cancer surgery, and after ileostomy closure, the AL were diagnosed; the interval from cancer surgery to diagnosis of AL was 108, 98, 99, 101, and 92 days. The remaining one patient without a protective ileostomy received postoperative radiotherapy, and the AL was diagnosed on the 169th day after cancer surgery. The interval from AL diagnosis to admission was 20 days (IQR: 18-25 days) in patients in DLIST group and 28.5 days (IQR: 21-36.75 days) in patients in PD group ( $P < 0.001$ ).

On admission, patients in DLIST group had C-reactive protein (CRP) ( $105.82 \pm 52.17$  mg/L vs  $49.63 \pm 43.23$  mg/L,  $P < 0.001$ ), higher Procalcitonin(PCT) ( $4.66 \pm 3.08$  µg/L vs  $2.05 \pm 2.9$  µg/L,  $P = < 0.001$ ), higher white blood cells (WBC) ( $16 [9.25-19] \times 10^9/L$  vs  $8.1 [6.92-13.57] \times 10^9/L$ ,  $P < 0.001$ ), and higher incidence of pus cavity length > 5 cm (48 [63.16%] vs 8 [15.38%],  $P < 0.001$ ).

## 3.2. Ileostomy

In our study, ileostomy was performed before admission in 49 patients (41 in PD group, eight in DLIST group). Of those patients, 28 patients had undergone protective ileostomy during cancer surgery (26 in PD group [nine with loop ileostomy and 17 with end ileostomy] and two in DLIST group [two with loop ileostomy]). The remaining 21 patients had emergency ileostomy (15 in PD group [four with loop ileostomy and 11 with end ileostomy]; six in DLIST group [four with loop ileostomy and two with end ileostomy]). The length from anastomosis to anus was  $6.09 \pm 3.35$  cm in the 49 patients ( $6.57 \pm 4.36$  cm in DLIST group vs.  $6.09 \pm 3.03$  cm in PD group,  $p = 0.825$ ). A total of 28 patients achieved spontaneous

closure. The spontaneous closure rate was 62.5% (5/8) in patients with DLIST, and it was 51.12%(23 /41) in patients with PD. The spontaneous closure time was 34 days (IQR: 30-40 days) in DLIST group and was 52 days (IQR:50-65days) in PD group( $p < 0.001$ ).

### **3.3. Primary outcome**

Spontaneous closure of AL was achieved in 67 (52.34%) patients. There were 46 patients in DLIST group, for a spontaneous closure rate of 60.52%, and 21 patients in PD group, for a spontaneous closure rate of 40.38%. The median spontaneous closure time was 40days (IQR: 35-49days) in the DLIST group and 56 days (IQR: 50-76days) in the PD group. The unadjusted Cox regression analysis (HR = 2.155; 95% CI: 1.281-3.642;  $P = 0.004$ ) and adjusted Cox regression analysis (HR = 3.048; 95% CI: 1.787-5.197;  $P < 0.001$ ) showed that DLIST was a positive factor for spontaneous closure (Table 2, Figure 3). In addition, length from anastomosis to anus (adjusted HR = 1.215 ; 95% CI: 1.012-1.369 ;  $P < 0.001$  ) was also associated with spontaneous closure(Table 2).

Table 2  
univariable and multivariable cox- regression analysis of factors for spontaneous closure

Characteristic	univariable regression analysis			multivariable regression analysis		
	HR	95%CI	p	HR	95%CI	p
DLIST	2.155	1.281-3.642	0.004	3.048	1.787-5.197	<0.001
Female	1.173	0.754-1.823	0.479			
Age	0.983	0.961-1.006	0.123			
BMI	1.059	0.918-1.221	0.432			
Tumor stage						
I	Ref	--	--			
IIA	0.557	0.221-1.409	0.217			
IIB	0.495	0.192-1.281	0.147			
IIC	0.563	0.234-1.356	0.200			
IIIA	0.856	0.325-2.258	0.754			
IIIB	0.509	0.127-2.043	0.341			
IIIC	1.785	0.540-5.896	0.342			
Perioperative radiotherapy	0.045	0.001-2.675	0.137			
Neoadjuvant therapy	0.823	0.355-1.905	0.649			
Dissected lymph nodes number<12	0.502	0.159-1.587	0.241			
Laparoscopic cancer surgery	0.862	0.577-1.586	0.956			
Interval from cancer surgery to AL diagnosed	0.985	0.960-1.011	0.248			

Characteristic	univariable regression analysis			multivariable regression analysis		
	HR	95%CI	p	HR	95%CI	p
Interval from AL diagnosed to admission	0.324	0.963-1.013	0.324			
Length from anastomosis to anus	1.203	1.089-1.524	<0.001	1.215	1.012-1.369	<0.001
High ligation of the inferior mesenteric artery	0.661	0.262-1.670	0.382			
Ileostomy before admission	2.760	0.767-4.683	0.076			
Puncture after admission	0.767	0.461-1.277	0.308			
Length of pus cavity>5cm	0.841	0.557-1.270	0.411			
Hemoglobin	1.011	0.997-1.026	0.133			
WBC	0.990	0.974-1.007	0.255			
Platelet	0.999	0.997-1.001	0.317			
CRP	0.998	0.995-1.002	0.391			
PCT	0.817	0.519-1.441	0.522			
Alb	1.176	0.487-2.471	0.376			
Kidney injury	0.637	0.089-4.571	0.653			
Hepatic injury	0.832	0.491-1.410	0.495			
Respiratory function injury	0.178	0.036-1.854	0.258			
cirrhosis	0.779	0.246-2.461	0.670			
Diabetes mellitus	0.460	0.213-0.996	0.049	0.594	0.255-1.387	0.229
Smoking	0.662	0.385-1.137	0.135			

## 3.4. Secondary outcomes

The LOS was 54 days (IQR: 41.25-117 days) in the DLIST group and 112 days (IQR: 66.75-127.75 days) in the PD group. Kaplan-Meier analysis showed that the patients in DLIST group had a shorter LOS ( $P = 0.005$ , Figure 4A). In addition, adjusted Cox regression analysis showed that replacement of PD (HR = 2.893; 95% CI: 2.943-5.135;  $P < 0.001$ ) had a positive influence on reducing LOS. In the 67 patients with spontaneous closure, the LOS of the DLIST group was shorter (Kaplan-Meier,  $P < 0.001$ , Figure 4B), However, in the 61 patients without spontaneous closure, the LOS was comparable between the two groups (Kaplan-Meier,  $P = 0.228$ , Figure 4C).

The median hospitalization expense was \$18,721 (IQR: \$14,982-44,960) in the DLIST group and \$40,840 (IQR: \$20,932-50,529) in the PD group ( $P < 0.001$ ). The hospitalization expense for patients with spontaneous closure was lower in DLIST group (\$15,981 [IQR: \$13,987-17,912] vs. \$20,932 [IQR: \$18,412-22,981];  $P < 0.001$ ), while it was comparable between the two groups in patients without spontaneous closure (\$48,293 [IQR: \$44,764-51,739] vs. \$49,723 [IQR: \$44,872-50,982];  $P = 0.942$ ).

## 3.5. Definitive surgery for AL

All 61 patients without spontaneous closure received definitive surgery for AL. Within a week before definitive surgery for AL, a CT scan was performed, and AL was evaluated again. The reduction of the length of the pus cavity was significant in the DLIST group ( $6.64 \pm 3.18$  cm on admission vs.  $1.57 \pm 0.67$  cm before definitive surgery,  $P < 0.001$ ). Of the 31 patients receiving definitive surgery in the PD group, 10 patients had a pus cavity that could be reached by the drainage tube. The length of the pus cavity on admission was comparable with that before definitive surgery ( $1.61 \pm 0.70$  cm on admission vs  $1.53 \pm 0.58$  cm before definitive surgery,  $P = 0.682$ ). Among the 61 patients without spontaneous closure, the definitive surgery was showed in Table 3.

Table 3  
Definitive surgery for AL

	DLIST group	PD group
Number	30	31
Characteristics, No		
No ileostomy	27	13
With ileostomy before admission	3	18
Surgical process, No		
AL resection		
AL resection only	7	4
AL resection+ileostomy closure	0	4
Colostomy	20	9
Colostomy+closure of ileostomy	3	14

## 4. Discussion

According to the International Study Group of Rectal Cancer [14], AL after radical resection of colorectal cancer can be classified as grade A, B, or C. Grade C AL is generally the most serious, requiring emergency surgery. It seemed that once the AL occurred, the consequences would be serious, and most colorectal AL was grade C. According to a review, the incidence of grade C AL was approximate 60% in patients with AL[15]. In fact, grade C AL or incidence of emergency surgery for AL might be higher. For instance, in a national study in Denmark, emergency surgery was performed at rates as high as 85% in AL cases[16]. In addition, in a study performed in Laval University, 73% of AL cases were grade C in patients without a protective stoma[9]. As a result, the treatment of AL after colorectal surgery was mainly focused on the emergency surgery. The main objective of emergency surgery for AL was to achieve source control. In our experience, using the DLIST tube seemed to be a useful method to establish source control. In our previous study[12], the DLIST was placed in the study group during radical resection of rectal cancer, and it was shown that emergency surgery was necessary in only 15% of ALs, while 60% of ALs required emergency surgery in the control group. In addition, in another of our reports[17], more than 2000 ml of colonic fluid and pus could be drained out within 48 hours using the DLIST. Thanks to the design of the DLIST, continuous irrigation can thin out the thick colonic fluid and make it easier to drain. We have made full use of DLIST through washing and irrigation to remove the infections. This may be one of the mechanisms leading to the pus cavity shrinkage .

In our study, it was shown that spontaneous closure was associated with the placement of DLIST after AL occurred. In addition to the adequate drainage and removal of contaminants, the result seemed to be

associated with the influence of negative pressure on granulation tissue. The obvious and common manifestation of this influence is that significant shrinkage of the wound can be observed as the edge of the granulation would deform and contract under the negative pressure[18]. Furthermore, negative pressure therapy can clear white blood cells and inflammatory factors[19] and stimulate cellular proliferation, angiogenesis, and the formation of granulation tissue[20] of the granuloma. In our study, the DLIST tube was used to provide negative pressure after insertion into the pus cavity. The effect of the negative pressure was to improve the filling of granulation tissue into the pus cavity and resolve the leakage. The direct reactions in our present research were the obvious shrinkage of the pus cavity and the higher incidence of spontaneous closure in the DLIST group compared with the PD group. In recent years, researchers have tried to treat rectal AL using innovative drainage methods and have achieved good clinical outcomes in a few selected patients[9,10]. However, the rates were variable in different studies[21]. A Swedish study investigating a certain number of patients[11], showed that the general spontaneous closure rate seemed to be only about 50%-60% when using the EVAC and transanal irrigation. In theory, EVAC microstructure could have a better effect on forming granulation tissue and promoting granulation tissue shrinkage[18]. In our previous study[13], this was demonstrated to be true. After all, the special sponge tissue with its small holes can fill the whole pus cavity and distribute pressure evenly to the cavity wall. However, what cannot be ignored is that the larger diameter holes in the tubes allow thick infections to be removed more easily compared with the vacuum-assisted closure system. In addition, removal of the infection was another important factor for spontaneous closure. This may be why EVAC seemed to have no obvious advantage compared with transanal drainage in Weréen's study[11]. In our study, the spontaneous closure rate was about 60% when using DLIST. The opposing views might be that DLIST did not improve the spontaneous closure rate very significantly, compared with transanal drainage and vacuum-assisted closure system. However, it should be noted that in the previous studies focused on the two methods, most patients received a stoma. In our studies, only a small number of patients had stoma. In general, compared with EVAC, DLIST might be better in clearing the thick infection, thanks to continuous irrigation of normal saline and negative pressure and forming granulation tissue. However, it was difficult to distinguish the best drainage method according to the existing research. As a result, future randomized clinical trials are necessary.

There were limitations in our study. The first limitation is that the study was retrospectively performed in two centers using similar treatments. So, selection bias was likely present. The second limitation is that the spontaneous closure was diagnosed only after colonography confirmation. As a result, we thought that diagnosis was often not timely, which might lead to bias. The third limitation is that as transferred from different units the overall number of operated cases and percentage of AL unfortunately is not possible. The fourth limitation is that the endoscopy-related information was lacking. Mucosal inflammation (with ulcers, erosion, and so on) may influence spontaneous closure time, so information regarding mucosal inflammation should be collected in future studies. In addition, our experience indicates that perioperative radiotherapy may be a very important factor for the failure of spontaneous closure. (In the present study, only four patients had perioperative radiotherapy, and spontaneous closure was not achieved in all four). However, in the present study, we could not conclude from the regression

results that postoperative radiotherapy was associated with spontaneous closure. The main reason might be that the number of patients with perioperative radiotherapy was so small (four patients). Future studies should focus on this potential factor. An other limitation was that the general situation of patients in DLIST group was worse. However, we have to understand that a group of patients with worse baseline data can achieve better efficacy. It seemed to be a more favorable proof.

In addition, it might be that patients receiving the standard of care, namely surgery with end colostomy or creation of a protective ileostomy for quick and effective control. We grant that surgical control of the source of infection is more direct, faster, and more thorough than all drainage methods. Actually, symptomatic patients always had a purulent cavity and poor drainage. Patients with AL should of course undergo laparotomy at an early stage. In addition, if there was a source of infection accumulating near the AL, the operation required not only devascularization but also debridement around the AL. As a result, simple ileostomy may not solve the problem quickly. In other words, patients might still be symptomatic after ileostomy if the drainage mode did not change. The perfect operation should be take-down anastomosis plus colostomy. However, the interval from AL diagnosis to admission was 20 (18-25) days in the DLIST group. It meant that the adhesion had gradually formed, and the surgery might cause secondary injury around the leakage. We used to attempt the surgical control in very early years, but in some patients, the AL cannot be exposed well. We had to perform colostomy in a hurry, and eventually we had a distal colonic stump fistula in addition to the unresolved AL. We feel that one should be cautious about laparotomy in patients with abdominal infection following leakage one month after the first operation, because it is like a trap. The early devascularization is a good method, but sometimes it might be risky to expose the AL during surgery. As a result, when considering the complications of the surgical control, we chose to place the DLIST as often as possible for irrigation and drainage.

## Conclusion

Placing a DLIST is an effective method to treat AL following rectal cancer surgery. Compare with PD, the cost of DLIST for treatment of AL is lower, and the length of stay is shorter.

## Abbreviations

AL=Anastomotic leakages;

CRP=C-reactive protein;

DLIST=Double-lumen irrigation-suction tubes;

EVAC=Endoscopic vacuum-assisted closure;

ISGRC=International Study Group of Rectal Cancer;

LOS=length of stay;

PCT=Procalcitonin;

PD= passive drainage;

SIRS=systemic inflammatory response syndrome;

White blood cells=WBC.

## **Declarations**

### **Ethics approval and consent to participate:**

The protocol for this research project has been approved by Committee of Jinling Hospital, Approval No. NJZY-21-04-0161, and .Committee of Jinling Hospital, Approval No. JNYY-10623. All subjects provided signed informed consent. All methods were carried out in accordance with relevant guidelines and regulations.

### **Consent for publication:**

Not applicable

### **Availability of data and materials:**

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

### **Competing interests:**

The authors declare that they have no competing interests.

### **Funding:**

None

### **Authors' contributions:**

Risheng Zhao and Weiliang Tian provide research objects. Xin Xu; Zheng Yao and Risheng Zhao collected and analysed the data; Zheng Yao; Ming Huang and Weiliang Tian wrote the main manuscript text; Xin Xu, prepared figures. Zheng Yao designed the research. Zheng Yao was the correspondence author. Weiliang Tian revised the manuscript. Ming Huang and Weiliang Tian were the first authors.

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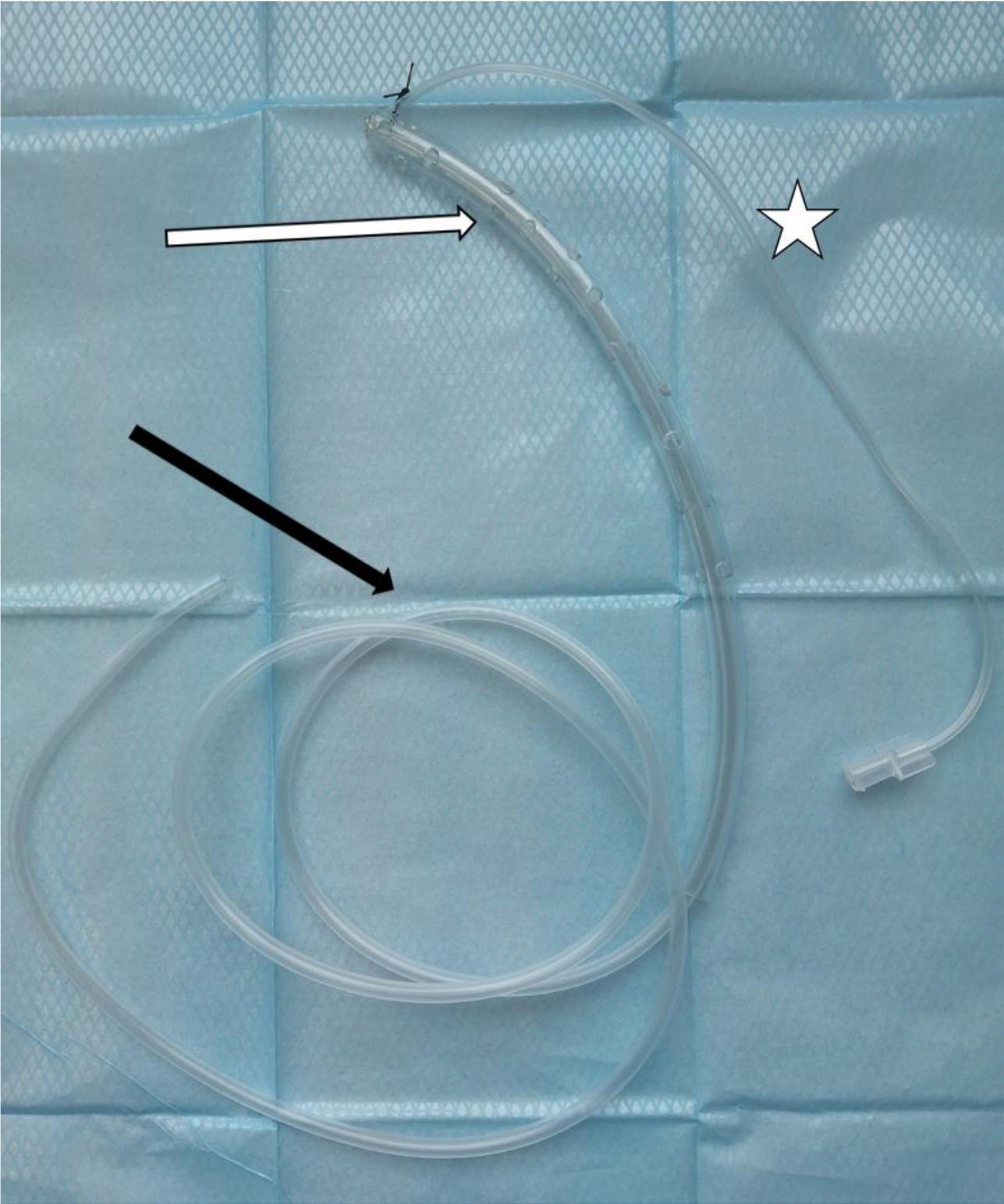
Not applicable

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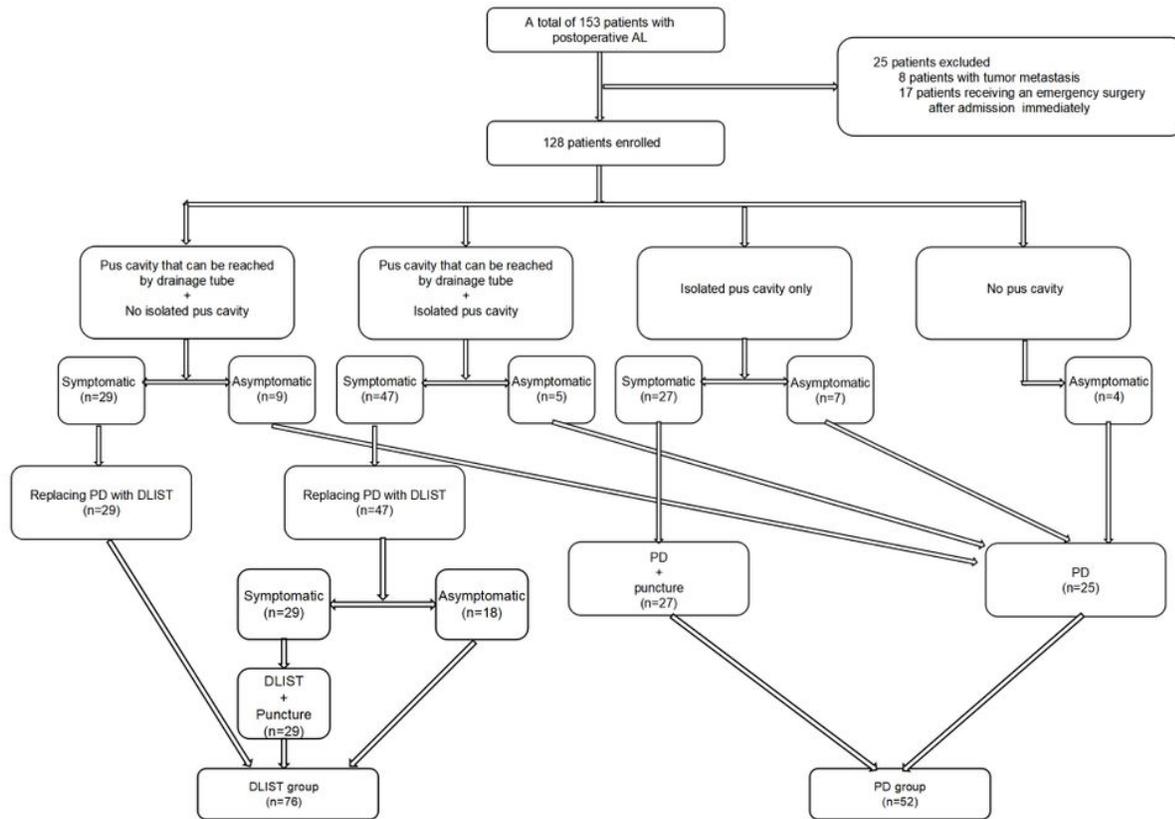
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## Figures



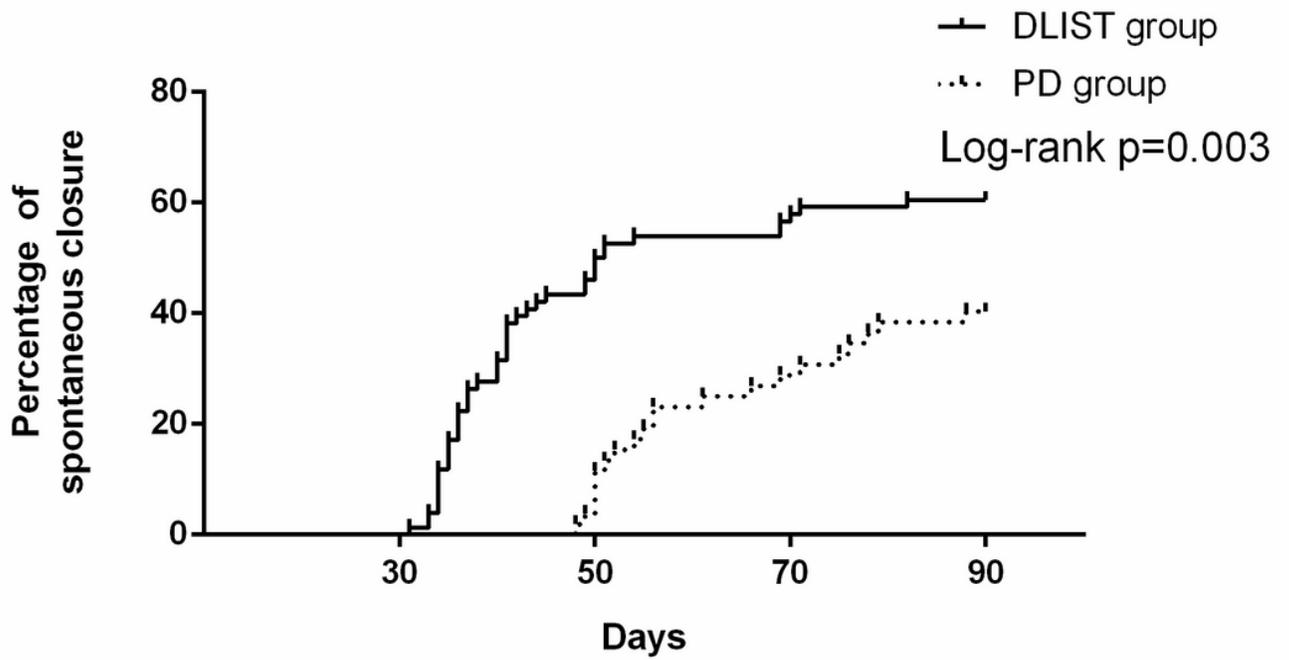
**Figure 1**

Double-lumen irrigation–suction tube consist of irrigation catheter ( ), suction catheter (identified by black arrow), and end-closed supporting pipe which was riddled with holes with diameter of about 3mm (the distance between each hole is about 1cm , identified by white arrow).



**Figure 2**

A total of 153 patients with postoperative AL after rectal cancer surgery were transferred to our centers. Of these, 8 patients with tumor metastasis during the treatment and 17 patients receiving emergency surgery immediately after admission were excluded from the study; thus, 128 patients were enrolled in our study. According to whether or not the passive drainage placed during the rectal cancer surgery was replaced with the DLIST, patients were divided into a passive drainage (PD) group and a double-lumen irrigation-suction tube (DLIST) group.

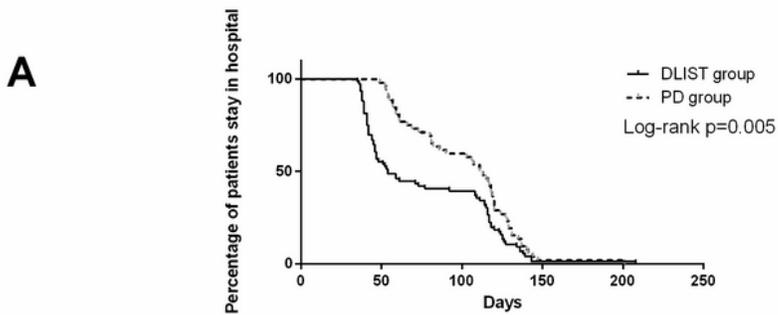


Numbers at risk

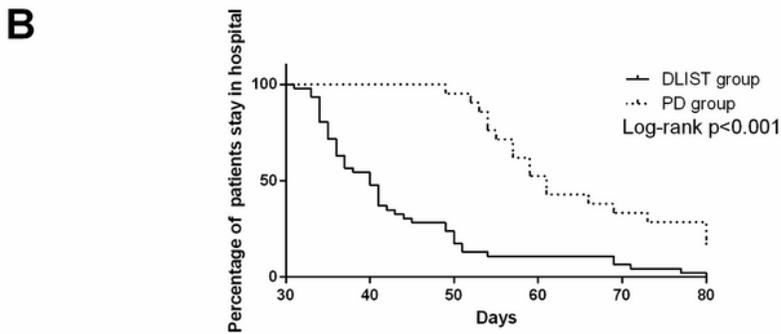
DLIST group	00	02	37	44	46
PD group	00	00	05	15	21

**Figure 3**

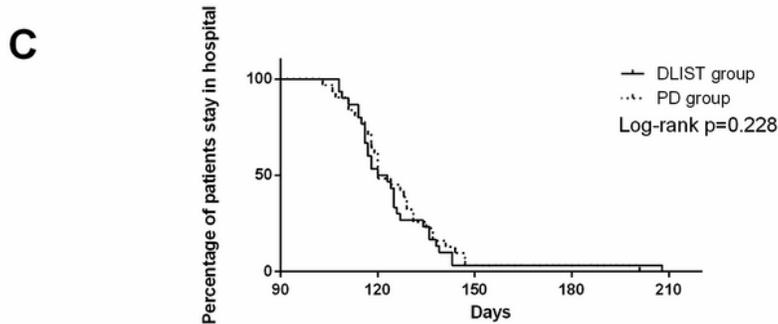
There were 46 patients in DLIST group, for a spontaneous closure rate of 60.52%, and 21 patients in PD group, for a spontaneous closure rate of 40.38%.



Numbers at risk	76	42	30	01	01	00
DLIST group						
PD group	52	51	31	01	01	00



Numbers at risk	46	23	11	05	03	00
DLIST group						
PD group	21	21	20	11	07	03



Numbers at risk	30	15	01	01	00
DLIST group					
PD group	31	15	01	01	00

**Figure 4**

Kaplan-Meier analysis showed that the patients in DLIST group had a shorter LOS ( $P = 0.005$ , Figure 4A). In addition, adjusted Cox regression analysis showed that replacement of PD (HR = 2.893; 95% CI: 2.943-5.135;  $P < 0.001$ ) had a positive influence on reducing LOS. In the 67 patients with spontaneous closure, the LOS of the DLIST group was shorter (Kaplan-Meier,  $P < 0.001$ , Figure 4B), However, in the 61 patients

without spontaneous closure, the LOS was comparable between the two groups (Kaplan-Meier,  $P = 0.228$ , Figure 4C).