

# New Anastomosis Technique to Prevent Anastomotic Leakage in Laparoscopic Anterior Resection for Rectal Cancer, Especially Upper Rectal Cancer

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**Abstract.** *Background/Aim:* Anastomotic leakage (AL) is a major problem in rectal cancer surgery. To prevent AL, we developed a side-to-side anastomosis technique using a circular stapler and termed it the circular side stapling technique (CST). We herein report the method and outcome of the CST. *Patients and Methods:* In this study, we analyzed 154 patients with stage 0 to III rectal cancer who underwent curative laparoscopic low anterior resection. Perioperative factors and complications were compared between the CST and usual double stapling technique (DST). *Results:* The CST was performed in 110 of the 154 patients. When comparing the outcomes of patients with upper rectal cancer, AL occurred in no patients in the CST group and in three patients in the DST group ( $p=0.011$ ). The CST prevented AL in all patients with upper rectal cancer. *Conclusion:* The CST is a safe and useful procedure in laparoscopic anterior resection. This technique can prevent AL, especially in patients with upper rectal cancer.

Rectal cancer is a common and lethal disease worldwide. It constitutes around one-third of all cases of colorectal cancer (1). Rectal cancer continues to be a major global health challenge and a frequent cause of cancer-related mortality and morbidity. The main treatment choice for rectal cancer is surgery, such as anterior resection. One option for rectal cancer resection is the laparoscopic approach. Randomized

clinical trials (COREAN, COLOR II, and MRC CLASSIC trials) have demonstrated comparable long-term local recurrence, disease-free survival, and overall survival between open and laparoscopic approaches to rectal cancer (2-5).

However, anastomotic leakage (AL) is still one of the most frequent complications after rectal cancer surgery. The reported incidence of AL after anterior resection varies from 6% to 17% even in laparoscopic surgery (6-8). Additionally, AL might raise concerns about local recurrence and may worsen the prognosis of patients with rectal cancer (9). Therefore, despite great advances in laparoscopic surgery, the risks of anastomotic complications persist.

Some studies have shown that placement of a transanal drainage tube to reduce the pressure on the anastomotic site can help to prevent AL (10, 11). Chen *et al.* (10) showed that a transanal drainage tube could significantly reduce the incidence of AL (relative risk, 0.42; 95% confidence interval=0.31-0.58;  $p<0.00001$ ). Gadiot *et al.* (12) reported that anti-traction sutures were useful to reduce AL.

We previously evaluated the anastomosis site in patients with AL in our Department (13). We found that AL often occurred where the two staples (placed by a circular stapler and linear stapler) crossed when using the usual double stapling technique (DST). To prevent crossing of the two staples, we developed a circular side stapling technique (CST) that is performed during colorectal anastomosis (14).

In this study, we analyzed the outcomes of rectal cancer surgery with the CST and usual DST in our Institute. We found that the CST reduced the incidence of AL, especially in patients with upper rectal cancer.

## Patients and Methods

*Patients.* The CST was developed and introduced at the Department of Surgery and Science of the Graduate School of Medical Sciences, Kyushu University in 2013. The present study included patients who underwent anterior resection from January 2013 to December 2018 at our Department. In total, 184 patients underwent anterior

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resection during this period. In this study, 154 patients with stage 0 to III rectal cancer were analyzed. The 154 patients comprised 93 men and 61 women (Table I). Their mean age was 64.3±11.7 years. Sixty-three patients had a tumor in the rectosigmoid colon, 64 in the upper rectum, and 27 in the lower rectum. Among the 154 patients, 110 (71.4%) underwent the CST for anastomosis. The protocol for this research project has been approved by a suitably constituted Ethics Committee of the Institution (Kyushu University Ethics Committee Approval No. 2019-209), and it conforms to the provisions of the Declaration of Helsinki. Written informed consent was obtained from all patients.

*CST method.* The CST method has been previously described (14). In brief, after removing the specimen, an anvil rod was inserted through the side of the colon wall. The entry hole in the colon was then closed with a linear stapler device. Intracorporeally, the shaft of the anastomosis device was pierced through the side of the rectal wall, and colorectal side-to-side anastomosis was then performed. We ensured that the staple line of the rectum was not involved in the anastomosis site during this procedure. After the anastomosis, we performed an air leak test and inserted a transanal drainage tube.

*Preoperative factors.* The operative duration, blood loss, perioperative complications, and AL were analyzed in this study. The Clavien-Dindo grading system was used to assess complications.

*Statistical analysis.* Statistical analysis was performed using JMP 14.0 software (SAS Institute, Cary, NC, USA). The  $\chi^2$  test, Fisher's exact test, and one-way analysis of variance were used as appropriate. A *p*-value of <0.05 was considered statistically significant.

**Results**

*Patient characteristics.* From January 2013 to December 2018, 184 patients underwent anterior resection. Among these patients, 154 had stage 0 to III rectal cancer. We analyzed these 154 patients who underwent complete resection.

The patients' clinical stages were stage 0 (n=2), stage I (n=44), stage II (n=38; IIA in 36, IIB in 1, and IIC in 1), and stage III (n=70; IIIA in 18, IIIB in 47, and IIIC in 5).

The duration of the operation was 253.9±84.3 min, and the amount of bleeding was 50.8±99.1 g. A covering stoma was created in 56 patients. AL occurred in five patients (3.2%).

*Comparison of outcomes between CST and DST.* Next, we compared the outcomes between the CST and DST (Table II). The CST was performed for colorectal anastomosis in patients with rectosigmoid cancer. The CST was performed in 64% (41/64) of patients with upper rectal cancer, and the DST was performed in 36% (23/64) of patients. The CST was performed in 22.2% (6/27) of patients with lower rectal cancer. As the location of the tumor became lower, the percentage of patients in whom the CST was performed decreased (*p*<0.0001). The duration of the operation was longer in the DST group (*p*<0.0001). There was no significant difference in the amount of bleeding between the

Table I. *Patient characteristics (n=154).*

Factor		N (%)
Age		64.3±11.7
Gender	Male	93 (60.4)
	Female	61 (39.6)
Stage	0	2 (1.3)
	I	44 (28.6)
	IIA	36 (23.4)
	IIB	1 (0.6)
	IIC	1 (0.6)
	IIIA	18 (11.7)
	IIIB	47 (30.5)
Location	IIIC	5 (3.2)
	Rectosigmoid	63 (40.9)
	Upper rectum	64 (41.6)
Anastomosis	Lower rectum	27 (17.5)
	CST	110 (71.4)
Duration of operation (min)	DST	44 (28.6)
		253.9±84.3
Bleeding (g)		50.8±99.1
Covering stoma	None	98 (63.6)
	Created	56 (36.4)
Anastomotic leakage	None	149 (96.8)
	Present	5 (3.2)

CST and DST. A covering stoma was created in most patients in the DST group (*p*<0.0001). This might have been the reason for the longer operative duration in the DST group. The hospital stay was longer in the DST group (*p*<0.0001). The DST was associated with more complications than the CST (*p*=0.025), which explains the longer hospital stay in the DST group. Two (1.8%) patients in the CST group and three (6.8%) patients in the DST group developed AL (*p*=0.13).

*Comparison of patients with upper and lower rectal cancer.* Because all patients with rectosigmoid cancer underwent CST, we next analyzed the outcomes in patients with upper and lower rectal cancer (Table III). The CST was more frequently performed in patients with upper rectal cancer (*p*=0.0002). The operative duration was longer in the DST group (*p*<0.0001), as mentioned above. A covering stoma was created in most patients in the DST group (*p*<0.0001). The hospital stay was longer in the DST group (*p*=0.0001). There was no difference in the occurrence of complications between the CST and DST (*p*=0.49). Additionally, there was no difference in the occurrence of AL between the two procedures (*p*=0.26).

*CST in patients with upper rectal cancer.* Next, we compared the CST and DST in patients with upper rectal cancer (Table IV). The operative duration was longer in the DST group (*p*=0.015). A covering stoma was created in most patients in

Table II. Comparison between circular side stapling technique (CST) and double stapling technique (DST).

	CST (n=110, %)	DST (n=44, %)	p-Value
Location			
Rectosigmoid	63 (57.3)	0	<0.0001
Upper rectum	41 (37.3)	23 (52.3)	
Lower rectum	6 (5.4)	21 (47.7)	
Duration of operation (min)	232.3±78.3	308±74.6	<0.0001
Bleeding (g)	46±104.4	62.9±84.4	0.3
Covering stoma			
None	97 (88.2)	1 (2.3)	<0.0001
Created	13 (11.8)	43 (97.7)	
Hospital stay (days)	10.3±4.9	18.8±9.7	<0.0001
Complication			
Clavian-Dindo classification			
0	87 (79.1)	25 (56.8)	0.025
1	4 (3.6)	1 (2.3)	
2	12 (10.9)	10 (22.7)	
3	7 (6.4)	8 (18.2)	
Anastomotic leakage			
None	108 (98.2)	41 (93.2)	0.13
Present	2 (1.8)	3 (6.8)	

Table III. Comparison between circular side stapling technique (CST) and double stapling technique (DST) in upper and lower rectum (n=91).

	CST (n=47, %)	DST (n=44, %)	p-Value
Location			
Upper rectum	41 (87.2)	23 (52.3)	0.0002
Lower rectum	6 (12.8)	21 (47.7)	
Duration of operation (min)	266.2±90	307.9±74.6	0.017
Bleeding (g)	46±62.1	62.9±84.4	0.28
Covering stoma			
None	36 (76.6)	1 (2.3)	<0.0001
Created	11 (23.4)	43 (97.7)	
Hospital stay (days)	11.7±6.2	18.8±9.7	0.0001
Complication			
Clavian-Dindo classification			
0	33 (70.2)	25 (56.8)	0.49
1	1 (2.1)	1 (2.3)	
2	9 (19.2)	10 (22.7)	
3	4 (8.5)	8 (18.2)	
Anastomotic leakage			
None	46 (97.8)	41 (93.2)	0.26
Present	1 (2.2)	3 (6.8)	

the DST group ( $p<0.0001$ ). The hospital stay was longer in the DST group ( $p=0.0004$ ). The DST was associated with a slightly higher complication rate than the CST ( $p=0.1$ ). No patients in the CST group and three patients in the DST group developed AL ( $p=0.011$ ). The CST prevented AL in patients with upper rectal cancer.

*Patients with AL.* Finally, we analyzed the patients with AL. Five patients developed AL, and all were male. The location of the tumor was rectosigmoid in one patient, upper rectum in three, and lower rectum in one. The CST was performed in two patients and the DST was performed in three. Three patients had a covering stoma and two did not. Two patients underwent an emergency operation for treatment of the AL. A covering stoma was not created in these two patients. The other three patients were treated conservatively; these patients had a covering stoma. The presence of a covering stoma spared patients from requiring an emergency operation for AL.

In a comparison of patients with and without AL, we found that male patients, patients who drank alcohol more than three times a week, and patients with diabetes had a significantly higher rate of AL (Table V). Additionally, patients with a high Brinkman index tended to have a higher incidence of AL. Male patients with rectal cancer who also have diabetes, a drinking habit, and/or a smoking habit should be considered to be at higher risk of AL, and a covering stoma should be created during the primary operation for these patients.

## Discussion

In our previous study, we introduced the CST in a series of 30 patients (14). These 30 patients had fairly good outcomes. Since then, we have performed the CST in more than 180 patients. In the present study, we evaluated the efficacy and safety of the CST for rectal anastomosis to reduce complications. We conclude that the CST is safe and can prevent AL, especially in patients with upper rectal cancer.

In previous studies, the incidence of AL during anterior resection ranged from about 6% to 17% (2, 15-18). In those studies, the DST was used for colorectal anastomosis. In a Japanese cohort study (19), the incidence of AL was approximately 10% among patients who underwent anterior resection using the DST. The DST is well known and has been frequently used as a method to create a colorectal anastomosis in anterior resection (20). The main problem associated with this method is the overlap of staples, which are placed by a linear stapler and circular stapler (13). When the DST is performed, the staples from the linear stapler and circular stapler intersect at two points. We previously showed that these intersections are the major points at which AL develops (13). Therefore, we concluded that the DST is not the best method for colorectal anastomosis in anterior resection. To prevent AL, we previously compared the anastomotic strength among several anastomosis methods using animal models (21). In a comparison of the single stapling technique, DST, and side-to-side technique, we

Table IV. Comparison between circular side stapling technique (CST) and double stapling technique (DST) in upper rectum (n=64).

	CST (n=41, %)	DST (n=23, %)	p-Value
Duration of operation (min)	257.6±91.4	311.3±76.9	0.015
Bleeding (g)	43.3±60.6	81.3±107.4	0.12
Covering stoma			
None	33 (80.5)	1 (4.3)	<0.0001
Created	8 (19.5)	22 (95.7)	
Hospital stay (days)	11.2±5.3	21.9±12.1	0.0004
Complication			
Clavian-Dindo classification			
0	30 (73.2)	12 (52.2)	0.1
2	8 (19.5)	5 (21.7)	
3	3 (7.3)	6 (26.1)	
Anastomotic leakage			
None	41 (100)	20 (87.0)	0.011
Present	0 (0)	3 (13.0)	

showed that the strongest anastomosis was the side-to-side anastomosis created by a circular stapler. This result was as same as previously reported study by Tomori *et al.* (22). Therefore, we introduced a side-to-side anastomosis technique (the CST) in colorectal anastomosis to prevent AL. The incidence of AL was lower in the CST than in the DST. In patients with upper rectal cancer, no AL occurred when using the CST. Thus, the CST can prevent AL.

The incidence of rectal cancer is increasing, and is approximately the second most common lesion among patients with colorectal cancer (23). The upper rectum is the most common site of rectal cancer (23). Our study indicates that the CST may be a good choice to prevent AL in patients with rectal cancer, especially upper rectal cancer.

Our CST can be performed when the length of the remnant rectum is adequate, such as in patients with rectosigmoid cancer and upper rectal cancer. Because the staple line produced by the linear stapler should be avoided, the length of the remnant rectum should be at least 3 to 4 cm. This means that the CST is difficult to perform in patients with only lower rectal cancer. In this study, the CST was performed in only six patients with lower rectal cancer. A more effective technique with which to create the anastomosis and prevent AL is needed when treating patients with lower rectal cancer.

Several known risk factors for AL are the anastomosis itself, the blood flow in the anastomosis, and the tension in the anastomosis. The patient's status is also an important risk factor for AL. Patients with severe diabetes, low nutrition, advanced cancer, and old age are at higher risk. Our analysis of five patients with AL showed that male sex, diabetes, and habitual drinking of alcohol were associated with a

Table V. Comparison between cases with anastomotic leakage (AL) and without AL.

	AL (n=5, %)	No AL (n=149, %)	p-Value
Age	64.4±11.9	63.8±5.8	0.57
Gender			
Male	5 (100)	88 (59)	0.023
Female	0 (0)	61 (41)	
Location			
Rectosigmoid	1 (20)	62 (41.6)	0.58
Upper rectum	3 (60)	61 (40.9)	
Lower rectum	1 (20)	26 (17.5)	
Alcohol			
No-Social	0 (0)	69 (46.3)	0.013
Three times/week or more	5 (100)	80 (53.7)	
Brinkman index	688±393.1	371.3±513.3	0.07
Diabetes			
No	3 (60)	126 (84.6)	0.19
Yes	2 (40)	23 (15.4)	
Duration of Operation (min)	323.2±64.8	251.6±84.1	0.033
Bleeding (g)	107±114.6	49.0±98.5	0.16
Covering stoma			
No	2 (40)	96 (64.4)	0.27
Created	3 (60)	53 (35.6)	

significantly higher rate of AL. Additionally, patients who frequently smoke tend to have a high incidence of AL. When treating these patients, we should pay attention to the risk of AL. One solution for these patients may be placement of a covering stoma. Patients with a covering stoma avoided an emergency operation in the present study. The treatment for AL with a covering stoma involves simple drainage and antibiotics. When treating high-risk patients (male sex, diabetes, and drinking and smoking habits), we should consider a covering stoma to avoid an extra operation. One method used to prevent AL is to check the blood flow at the anastomosis site because adequate blood flow at this site is important in preventing AL. Angiography with indocyanine green (ICG) fluorescence has recently been attracting attention (24). Ishii *et al.* (25) retrospectively evaluated the usefulness of ICG in preventing AL. Shen *et al.* (26) performed a meta-analysis of ICG in low anterior resection and found that intraoperative use of ICG was associated with a lower AL rate (odds ratio=0.30; 95% confidence interval=0.19-0.49;  $p<0.001$ ;  $I^2=0\%$ ). Checking the blood flow with ICG fluorescence angiography is a useful method to prevent AL in patients with rectal cancer. However, the device required to perform this procedure might be expensive. The CST can also prevent AL, especially in patients with upper rectal cancer; therefore, checking the blood flow with an ICG camera may not be needed when using the CST.

Sprenger *et al.* (18) reported the long-term prognostic impact of surgical complications in patients with rectal cancer. They evaluated the impact of surgical complications on oncological outcomes in 799 patients with locally advanced rectal cancer treated within the German CAO/ARO/AIO-94 randomized trial. The authors reported that 10-year overall survival was worse in patients with than without AL (51.0% vs. 65.2%, respectively;  $p=0.020$ ). Therefore, perioperative complications including AL should be avoided.

A limitation of this study is its retrospective nature. Another limitation is that the patients' background characteristics were not uniform between the CST and DST groups. To precisely evaluate the usefulness of the CST in anterior resection, a prospective study comparing the CST and DST must be performed.

Operations for rectal cancer require highly skilled techniques and have high complication rates. Complications result in poor outcomes and must be prevented. Our CST is one method by which to reduce AL. We must still prevent other complications to ensure good oncological outcomes for patients with rectal cancer.

## Conflicts of Interest

The Authors declare no conflicts of interest regarding this article.

## Authors' Contributions

K.A. analyzed the data and wrote the manuscript. N.K., Y.F. T.J., K.H., H.Q. Y.H. and R.N. collected the data and checked the manuscript. Y.N., Y.K., E.O. and M.M. checked the manuscript.

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## References

- Global Burden of Disease Cancer C, Fitzmaurice C, Allen C, Barber RM, Barregard L, Bhutta ZA, Brenner H, Dicker DJ, Chimed-Orchir O, Dandona R, Dandona L, *et al.*: Global, regional, and national cancer incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life-years for 32 cancer groups, 1990 to 2015: A systematic analysis for the global burden of disease study. *JAMA Oncol* 3(4): 524-548, 2017. PMID: 27918777. DOI: 10.1001/jamaoncol.2016.5688
- Guillou PJ, Quirke P, Thorpe H, Walker J, Jayne DG, Smith AM, Heath RM, Brown JM and group MCt: Short-term endpoints of conventional *versus* laparoscopic-assisted surgery in patients with colorectal cancer (mrc classic trial): Multicentre, randomised controlled trial. *Lancet* 365(9472): 1718-1726, 2005. PMID: 15894098. DOI: 10.1016/S0140-6736(05)66545-2
- Kang SB, Park JW, Jeong SY, Nam BH, Choi HS, Kim DW, Lim SB, Lee TG, Kim DY, Kim JS, Chang HJ, Lee HS, Kim SY, Jung KH, Hong YS, Kim JH, Sohn DK, Kim DH and Oh JH: Open *versus* laparoscopic surgery for mid or low rectal cancer after neoadjuvant chemoradiotherapy (corean trial): Short-term outcomes of an open-label randomised controlled trial. *Lancet Oncol* 11(7): 637-645, 2010. PMID: 24837215. DOI: 10.1016/S1470-2045(10)70131-5
- van der Pas MH, Haglund E, Cuesta MA, Furst A, Lacy AM, Hop WC, Bonjer HJ and Group COcLoORIS: Laparoscopic *versus* open surgery for rectal cancer (color ii): Short-term outcomes of a randomised, phase 3 trial. *Lancet Oncol* 14(3): 210-218, 2013. PMID: 23395398. DOI: 10.1016/S1470-2045(13)70016-0
- Acuna SA, Chesney TR, Ramjist JK, Shah PS, Kennedy ED and Baxter NN: Laparoscopic *versus* open resection for rectal cancer: A noninferiority meta-analysis of quality of surgical resection outcomes. *Ann Surg*, 2018. PMID: 30339624. DOI: 10.1097/SLA.0000000000003072
- Braga M, Frasson M, Vignali A, Zuliani W, Capretti G and Di Carlo V: Laparoscopic resection in rectal cancer patients: Outcome and cost-benefit analysis. *Dis Colon Rectum* 50(4): 464-471, 2007. PMID: 17195085. DOI: 10.1007/s10350-006-0798-5
- Liang X, Hou S, Liu H, Li Y, Jiang B, Bai W, Li G, Wang W, Feng Y and Guo J: Effectiveness and safety of laparoscopic resection *versus* open surgery in patients with rectal cancer: A randomized, controlled trial from china. *J Laparoendosc Adv Surg Tech A* 21(5): 381-385, 2011. PMID: 21395453. DOI: 10.1089/lap.2010.0059
- Lujan J, Valero G, Hernandez Q, Sanchez A, Frutos MD and Parrilla P: Randomized clinical trial comparing laparoscopic and open surgery in patients with rectal cancer. *Br J Surg* 96(9): 982-989, 2009. PMID: 19644973. DOI: 10.1002/bjs.6662
- Krurup PM, Nordholm-Carstensen A, Jorgensen LN and Harling H: Anastomotic leak increases distant recurrence and long-term mortality after curative resection for colonic cancer: A nationwide cohort study. *Ann Surg* 259(5): 930-938, 2014. PMID: 24045445. DOI: 10.1097/SLA.0b013e3182a6f2fc
- Chen H, Cai HK and Tang YH: An updated meta-analysis of transanal drainage tube for prevention of anastomotic leak in anterior resection for rectal cancer. *Surg Oncol* 27(3): 333-340, 2018. PMID: 30217286. DOI: 10.1016/j.suronc.2018.05.018
- Okuda J, Tanaka K, Kondo K, Asai K, Kayano H, Yamamoto M and Tanigawa N: Safe anastomosis in laparoscopic low anterior resection for rectal cancer. *Asian J Endosc Surg* 4(2): 68-72, 2011. PMID: 22776224. DOI: 10.1111/j.1758-5910.2011.00071.x
- Gadiot RP, Dunker MS, Mearadji A and Mannaerts GH: Reduction of anastomotic failure in laparoscopic colorectal surgery using antitraction sutures. *Surg Endosc* 25(1): 68-71, 2011. PMID: 20661752. DOI: 10.1007/s00464-010-1131-x
- Ikeda T, Kumashiro R, Taketani K, Ando K, Kimura Y, Saeki H, Oki E, Morita M, Akahoshi T, Hashizume M and Maehara Y: Endoscopic evaluation of clinical colorectal anastomotic leakage. *J Surg Res* 193(1): 126-134, 2015. PMID: 25103641. DOI: 10.1016/j.jss.2014.07.009
- Oki E, Ando K, Saeki H, Nakashima Y, Kimura Y, Hiyoshi Y, Imamura Y, Ohgaki K, Ito S, Morita M, Ikeda T and Maehara Y: The use of a circular side stapling technique in laparoscopic low anterior resection for rectal cancer: Experience of 30 serial cases. *Int Surg* 100(6): 979-983, 2015. PMID: 25590136. DOI: 10.9738/INTSURG-D-14-00202.1

- 15 Clinical Outcomes of Surgical Therapy Study G, Nelson H, Sargent DJ, Wieand HS, Fleshman J, Anvari M, Stryker SJ, Beart RW, Jr., Hellinger M, Flanagan R, Jr., Peters W and Ota D: A comparison of laparoscopically assisted and open colectomy for colon cancer. *N Engl J Med* 350(20): 2050-2059, 2004. PMID: 15141043. DOI: 10.1056/NEJMoa032651
- 16 Colon Cancer Laparoscopic or Open Resection Study G, Buunen M, Veldkamp R, Hop WC, Kuhry E, Jeekel J, Haglind E, Pahlman L, Cuesta MA, Msika S, Morino M, Lacy A and Bonjer HJ: Survival after laparoscopic surgery *versus* open surgery for colon cancer: Long-term outcome of a randomised clinical trial. *Lancet Oncol* 10(1): 44-52, 2009. PMID: 19071061. DOI: 10.1016/S1470-2045(08)70310-3
- 17 Shinji S, Ueda Y, Yamada T, Koizumi M, Yokoyama Y, Takahashi G, Hotta M, Iwai T, Hara K, Takeda K, Okusa M, Kan H, Uchida E and Yoshida H: Male sex and history of ischemic heart disease are major risk factors for anastomotic leakage after laparoscopic anterior resection in patients with rectal cancer. *BMC Gastroenterol* 18(1): 117, 2018. PMID: 30016941. DOI: 10.1186/s12876-018-0846-3
- 18 Sprenger T, Beissbarth T, Sauer R, Tschmelitsch J, Fietkau R, Liersch T, Hohenberger W, Staib L, Gaedcke J, Raab HR, Rodel C and Ghadimi M: Long-term prognostic impact of surgical complications in the german rectal cancer trial cao/aro/aio-94. *Br J Surg* 105(11): 1510-1518, 2018. PMID: 29846017. DOI: 10.1002/bjs.10877
- 19 Watanabe T, Miyata H, Konno H, Kawai K, Ishihara S, Sunami E, Hirahara N, Wakabayashi G, Gotoh M and Mori M: Prediction model for complications after low anterior resection based on data from 33,411 japanese patients included in the national clinical database. *Surgery* 161(6): 1597-1608, 2017. PMID: 28153378. DOI: 10.1016/j.surg.2016.12.011
- 20 Miller K and Moritz E: Circular stapling techniques for low anterior resection of rectal carcinoma. *Hepatogastroenterology* 43(10): 823-831, 1996. PMID: 8884297.
- 21 Ikeda T, Kumashiro R, Oki E, Taketani K, Ando K, Aishima S, Akahoshi T, Morita M and Maehara Y: Evaluation of techniques to prevent colorectal anastomotic leakage. *J Surg Res* 194(2): 450-457, 2015. PMID: 25544478. DOI: 10.1016/j.jss.2014.11.045
- 22 Tomori K, Eto K, Haruki K, Sugano H, Imaizumi Y, Kumamoto T, Takada N, Shimoyama Y and Yanaga K: Comparison of strength of anastomosis between four different techniques for colorectal surgery. *Anticancer Res* 40(4): 1891-1896, 2020. PMID: 32234877. DOI: 10.21873/anticancer.14143
- 23 Wang CB, Shahjehan F, Merchea A, Li Z, Bekaii-Saab TS, Grothey A, Colibaseanu DT and Kasi PM: Impact of tumor location and variables associated with overall survival in patients with colorectal cancer: A mayo clinic colon and rectal cancer registry study. *Front Oncol* 9: 76, 2019. PMID: 30838175. DOI: 10.3389/fonc.2019.00076
- 24 Sujatha-Bhaskar S, Jafari MD and Stamos MJ: The role of fluorescent angiography in anastomotic leaks. *Surg Technol Int* 30: 83-88, 2017. PMID: 28277591.
- 25 Ishii M, Hamabe A, Okita K, Nishidate T, Okuya K, Usui A, Akizuki E, Satoyoshi T and Takemasa I: Efficacy of indocyanine green fluorescence angiography in preventing anastomotic leakage after laparoscopic colorectal cancer surgery. *Int J Colorectal Dis* 35(2): 269-275, 2020. PMID: 31838580. DOI: 10.1007/s00384-019-03482-0
- 26 Shen Y, Yang T, Yang J, Meng W and Wang Z: Intraoperative indocyanine green fluorescence angiography to prevent anastomotic leak after low anterior resection for rectal cancer: A meta-analysis. *ANZ J Surg*, 2020. PMID: 32159273. DOI: 10.1111/ans.15809

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