Inflammatory Intestinal Diseases

Research Article

Inflamm Intest Dis 2024;9:55–61
DOI: 10.1159/000538025

Received: October 22, 2023
Accepted: February 19, 2024
Published online: February 26, 2024

Laparoscopy-Assisted Restorative Proctocolectomy with Ileal Pouch-Anal Anastomosis in Middle Colic Artery Ligation Immediately before Specimen Removal

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Keywords

Ulcerative colitis · Surgery · Ileal pouch-anal anastomosis · Late ligation of middle colic artery · Complication

Abstract

Introduction: Restorative proctocolectomy with ileal pouch-anal anastomosis (IPAA) is the surgical procedure for ulcerative colitis (UC). Intestinal ischemia may occur if the main blood vessels are ligated at an early stage of this surgery. Considering that the blood flow in the large intestine can be maintained by preserving the middle colic artery, we have used a new IPAA method: ligating the middle colic artery immediately before removal of the specimens ("M-method"). Here, we evaluated the M-method's clinical outcomes. ***Methods:*** Between April 2009 and December 2021, 13 patients underwent a laparoscopy-assisted IPAA procedure at our institution. The conventional method was used for 6 patients, and the M-method was used for the other 7 patients. We retrospectively analyzed the cases' clinical notes. ***Results:*** The M-method's rate of postoperative complications (Clavien-Dindo classification grade II or more) was significantly lower than that of the conventional method (14.2% vs. 83.3%). The M-method group's postoperative stay period was also significantly shorter (average 16.4 days vs. 55.5). There were significant differences in the albumin value and the ratio of the modified GPS score 1 or 2 on the 7th postoperative day between the M- and conventional methods (average 3.15 vs. 2.5, average 4/7 vs. 6/6). However, it is necessary to consider the small number of cases and the uncontrolled historical comparison. ***Conclusion:*** Late ligation of the middle colic artery may be beneficial for patients' post-surgery recovery and can be recommended for IPAAs in UC patients.

Introduction

Restorative proctocolectomy with ileal pouch-anal anastomosis (IPAA) is the surgical procedure of choice for ulcerative colitis (UC) [1, 2]. As the IPAA technique has evolved, laparoscopic [3, 4], and robotic [5, 6] surgical procedures for performing an IPAA by a minimally invasive approach have been described, but there have been

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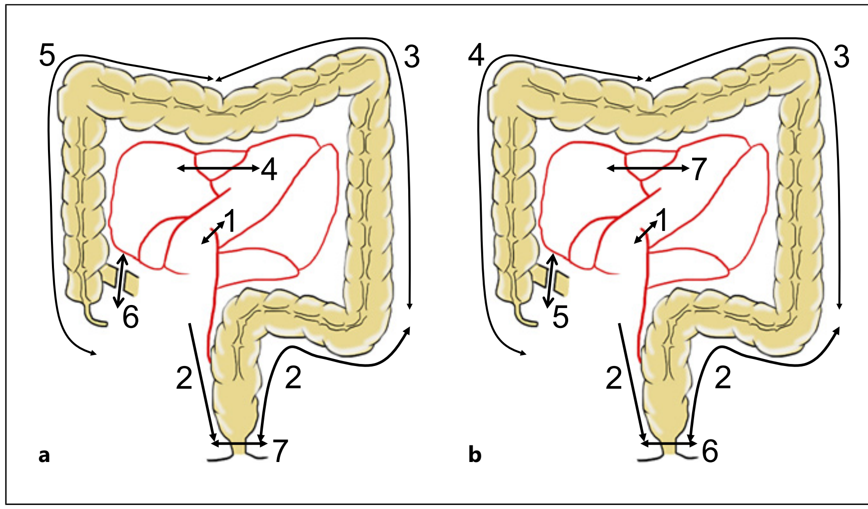

Fig. 1. Comparison of operative steps between the conventional method (**a**) and M-method (**b**).

no reports of standardized IPAA operative steps. We have also found no published description of the precise order of blood vessel ligation. Colonic ischemia causes injury due to local accumulation of lactic acid and cellular metabolic by products secondary to anaerobic glycolysis. Furthermore, colonic ischemia brings hemoconcentration, elevated white cell count, high anion gap lactic acidosis, positive D dimer test, hyperamylasemia, hyperkalemia, and hyperphosphatemia [7]. Hypoalbuminemia is an important risk factor for ischemic colitis [8]. Since the large intestine is long, intestinal ischemia may occur if the main blood vessels are ligated at an early stage of the surgery. Conventionally, blood vessels are ligated at an early stage of an IPAA, and the resected specimen exhibited ischemia. Considering that the blood flow in the large intestine can be maintained by leaving the middle colic artery intact, we changed the operative steps. Since then we have been performing IPAAs of ligating the middle colic artery immediately before removal of the specimens (we call this new technique the "M-method"). In the present study, we retrospectively compared the clinical data of conventional method with that of the M-method, and we assessed the M-method's usefulness.

Materials and Methods

This retrospective study was conducted at the surgical department of Teikyo University School of Medicine.

Patients

From April 2009 to December 2021, 13 patients with UC underwent a laparoscopy-assisted IPAA at our surgical department. We enrolled consecutive patients with no exclusion. From 2009 through 2018, we used the conventional method (n = 6 patients), and from 2020 through 2021 we used the M-method (n = 7). Written consent has been obtained from all patients and relevant persons (such as the parent or legal guardian) to publish the information, including photographs.

Ethical Considerations

The Institutional Review Board of Teikyo University School of Medicine (No. 16-032) approved this retrospective study of UC surgical cases.

Operative Steps

The details of our conventional method for conducting a laparoscopy-assisted stapled IPAA are as follows. The patient is placed in the Trendelenburg position with low lithotomy, legs apart. An optical trocar is placed at the umbilicus. Four trocars are placed at the left lower, left upper, right lower, right upper abdomen.

We start with the dissection of the intestinal membrane of the sigmoid colon. The inferior mesenteric artery is identified, clipped, and resected. The inferior mesenteric vein and left colic artery are also done.

We start with the dissection of the lateral attachments of the sigmoid and descending colon and perform a downwards dissection of the recto-sigmoid junction and of the superior rectum. The splenic colonic flexure is completely mobilized from the right side to the left by close dissection and vascular control. After all of the gastro-colic adherences are freed up, the mid-colonic vessels are ligated and the transverse meso-colon is transected using the vascular fusion closure device.

The ascending colon, the cecum, and the terminal ileum are mobilized until hepatic flexure. The ileocolic artery is preserved. Dissection of ileocolic vessels is performed near the colon. At this point, blood flow to the colon stops flowing. After the umbilical trocar is removed, a 5-cm incision is made, and the cecum and ileum are extracted through the incision. The ileum end is transected by the auto-suture device. The apex of the pouch is incised, and the auto-suture device is inserted and fired 3 times. The anvil of the circular stapler is placed at the apex and sutured. A blind end is closed by the auto-suture device. A stapled J-pouch with a length of 15 cm is created.

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Table 1. Background and clinical data of the 13 patients with ulcerative colitis

No.	Method	Year	Age	M/F	Ht, cm	BW, kg	BMI	Disease duration, year	Extent of inflammation	Recent endoscopic findings	Preoperative medication	Indication	Elective/emergency	Open or Lap	Hand-sewn or Stapled	Op time, min	Blood loss, mL	Postop. days	Complication: Clavien-Dindo grade
1	Conv	2009	47	M	167	53	19.0	7	Total	None	5-ASA, PRE, AZA	Refractory	Elective	Lap	S	480	597	51	Leakage:G-2
2	Conv	2010	37	M	170	85	29.4	18	Total	None	5-ASA	Cancer	Elective	Lap	S	600	180	30	(–)
3	Conv	2016	43	M	169	63	22.1	13	Total	None	5-ASA	Cancer	Elective	Lap	S	423	57	49	Outlet obstruction→surgery: G-3
4	Conv	2016	59	F	156	44	18.1	7	Total	None	5-ASA	Cancer	Elective	Lap	H	484	18	35	Ileus:G-2
5	Conv	2017	59	M	166	57	20.7	24	Total	None	5-ASA, PRE, AZA, TNF	Refractory	Elective	Lap	S	515	113	137	Infection, fever, sepsis, DIC, ileus:G-3
6	Conv	2018	69	M	171	52	17.8	40	Total	None	5-ASA, PRE	Cancer	Elective	Lap	H	525	33	31	Ileus:G-2
7	M-m.	2020	37	F	148	66	30.1	2	Total	None	5-ASA, PRE	Cancer	Elective	Lap	H	611	255	35	(–)
8	M-m.	2020	27	F	153	60	25.6	7	Total	Pouchitis	5-ASA, PRE, AZA, TNF	Refractory	Elective	Lap	S	434	23	12	(–)
9	M-m.	2021	31	M	172	46	15.5	14	Total	None	5-ASA, PRE	Cancer	Elective	Lap	H	481	133	10	Pelvic abscess→drainage: G-3
10	M-m.	2021	79	M	173	73	24.4	20	Total	None	5-ASA	Cancer	Elective	Lap	S	535	166	14	(–)
11	M-m.	2021	38	F	157	40	16.2	9	Total	None	5-ASA, PRE, AZA	Dysplasia	Elective	Lap	H	497	135	13	(–)
12	M-m.	2021	66	M	162	61	23.2	16	Total	Pouchitis	5-ASA, PRE	Cancer	Elective	Lap	S	473	151	18	(–)
13	M-m.	2021	29	F	153	47	20.1	8	Total	Pouchitis	5-ASA, PRE, AZA, TNF	Refractory	Elective	Lap	S	425	5	13	(–)

Conv, conventional; M-m., M-method; H, Hand-sewn; S, stapled; 5-ASA, 5-aminosalicylic acid; PRE, predonisolone; AZA, azathioprine; TNF, anti-TNFα.

With the intestinal tract put back at the abdominal cavity, the rectum is transected using the suturing device at the level of the pelvic floor. The specimen is extracted through an umbilical incision. The ileal pouch-to-rectum anastomosis is then created by the circular stapler. A loop ileostomy is performed. All of the remaining trocar sites are controlled and closed. The transanal catheter is inserted and sutured. The specimen is then sent for pathological examination.

Summary of Operative Steps

The summary of our conventional operative steps for a stapled IPAA is as follows (Fig. 1a): (1) IMA ligation, (2) pelvic operation, (3) freeing of the splenic flexure, (4) MCA ligation, (5) freeing of the right colon, (6) creation of ileal pouch, (7) anal canal dissection, (8) removal, (9) stapled anastomosis, and (10) creation of the ileostomy (Fig. 1a). Our conventional operative steps for a hand-sewn IPAA are as follows: (1) IMA ligation, (2) pelvic operation, (3) freeing of the splenic flexure, (4) MCA ligation, (5) freeing of the right colon, (6) creation of ileal pouch, (7) operation in the perineum, (8) anal canal dissection, (9) removal, (10) hand-sewn or stapled anastomosis, and (11) creation of the ileostomy.

In contrast, in the M-method, the operative steps for a stapled IPAA are as follows (Fig. 1b): (1) IMA ligation, (2) pelvic operation, (3) freeing of the splenic flexure, (4) freeing of the right colon, (5) creation of the ileal pouch, (6) anal canal dissection, (7) MCA ligation, (8) removal, (9) stapled anastomosis, and (10) creation of the ileostomy.

The operative steps for a hand-sewn IPAA are as follows: (1) IMA ligation, (2) pelvic operation, (3) freeing of the splenic flexure, (4) freeing of the right colon, (5) creation of the ileal pouch, (6) operation in the perineum, (7) anal canal dissection, (8) MCA ligation, (9) removal, (10) hand-sewn or stapled anastomosis, and (11) creation of the ileostomy.

The operator was only one who is well experienced at laparoscopic colorectal surgery but not at UC. His number of UC surgeries was 12 in 2009.

Postoperative Management

Broad-spectrum antibiotics are continued for 24 h postoperatively. An anesthesiologist removes the nasogastric decompression in the operating room. On the third postoperative day, the medical staff removed the patient's urinary catheter after detaching the epidural catheter. The transanal catheter is removed during the period from the seventh to tenth postoperative days.

We evaluated the 13 patients' perioperative serological data: pre-surgery and on the 1st, 3rd, 5th, and 7th postoperative days. The variables examined included the white blood cell (neutrophils, lymphocytes) counts and the levels of C-reactive protein, creatine kinase, albumin, and platelets.

Definitions

Postoperative complications were defined as those occurring after surgery by the date of the patient's discharge and were classified as Clavien-Dindo grade II or higher.

Data Comparison

The patient age, sex, body mass index (BMI), anastomosis method, operation time, blood loss, early complication rate, postoperative stay, and serological data were compared between the conventional and M-methods.

Table 2. Clinical comparison of the M-method and conventional method

Itmes	M-method	Conv.	*p* value
Age, years	43.8±20.3	52.3±11.9	0.3904
Male/female	3/4	5/1	0.1348
BMI	22.1±5.2	21.1±4.3	0.7162
Hand-sewn/stapled	3/4	2/4	0.7249
Op. time, min	493±63	504±58	0.7586
Blood loss, mL	124±85	166±219	0.6453
Complication	14.2% (1/7)	83% (5/6)	0.0128
Postoperative stay, days	16.4±8.5	55.5±40.9	0.0305

Statistical Analysis

Data were collected retrospectively onto a dedicated database from a review of the medical and nursing notes kept for each patient. The grouped data are expressed as the mean and standard deviation. Probability (p) values <0.05 were considered significant. JMP Pro ver. 15.1 software (SAS Institute, Cary, NC, USA) was used to perform the analyses.

Results

Background and Clinical Data of the Patients

Table 1 summarizes the background and clinical data of the 13 patients with UC. The conventional method was used from 2009 to 2018, and the M-method has been used since 2020.

Clinical Comparison of the M-Method and Conventional Method

Table 2 presents the clinical comparison between the M-method and conventional method. The M-method's complication rate was significantly lower than that of the conventional method (14.2% vs. 83.3%, $p = 0.0128$), and the postoperative stay of the M-method group of patients was significantly shorter than that of the conventional-method group (average 16.4 vs. 55.5 days, $p = 0.0305$). No significant between-group differences were observed regarding the patients' age, sex, BMI, anastomotic method, operative time, or blood loss (Table 2).

Comparison of Perioperative Data between the M-Method and Conventional Method

We compared the perioperative data at presurgery and on the 1st, 3rd, 5th, and 7th postoperative days between the M-method and conventional groups (Table 3). The albumin value on the 7th postoperative day in the M-method group was significantly higher than that of the conventional-method group (average 3.15 vs. 2.5 g/dL, $p = 0.0254$). The ratio of the Modified Glasgow Prognostic Score (mGPS) score 1 or 2 points on the 7th postoperative

Table 3. Perioperative data comparison between M-method and conventional

Items	Date	M-method	Conventional	*p* value
WBC	Presurgery	5,728±1,646	5,783±1,248	0.9481
	1POD	10,671±4,609	11,516±3,641	0.7242
	3POD	9,185±2,727	10,566±3,275	0.424
	5POD	8,585±873	7,900±943	0.6044
	7POD	10,771±1,454	10,133±1571	0.7712
CRP	Presurgery	0.36±0.16	0.27±0.18	0.7221
	1POD	5.40±4.46	7.00±3.81	0.5052
	3POD	8.97±6.76	13.3±6.38	0.2619
	5POD	4.56±4.70	4.82±2.73	0.9083
	7POD	3.74±3.14	6.37±7.78	0.4273
CK	Presurgery	92.8±29.7	92.3±96.0	0.9907
	1POD	338.2±153.1	644.2±181.2	0.2264
	3POD	461.5±169.5	477.8±183.1	0.9492
	5POD	116.2±42.7	129.5±46.1	0.8374
	7POD	48.5±15.0	52.8±16.2	0.851
Alb	Presurgery	3.9±0.30	3.88±0.42	0.6254
	1POD	2.88±0.21	2.8±0.48	0.6773
	3POD	2.68±0.32	2.55±0.44	0.536
	5POD	2.97±0.40	2.65±0.56	0.257
	7POD	3.15±0.45	2.5±0.46	0.0254
CRP/Alb	Presurgery	0.099±0.146	0.077±0.115	0.7715
	1POD	1.89±1.55	2.49±1.45	0.4926
	3POD	3.48±2.78	5.42±2.75	0.2359
	5POD	1.72±2.07	1.95±1.34	0.8225
	7POD	1.28±1.27	2.95±3.90	0.304
N/L	Presurgery	3.47±1.40	3.55±2.42	0.9406
	1POD	26.2±33.9	19.8±22.3	0.7772
	3POD	16.5±4.88	15.9±5.28	0.9333
	5POD	9.74±2.4	10.4±2.6	0.8519
	7POD	7.62±1.61	10.62±1.74	0.2993
Platelet/Lymph	Presurgery	0.026±0.010	0.028±0.019	0.8584
	1POD	0.050±0.039	0.038±0.036	0.6802
	3POD	0.042±0.033	0.040±0.016	0.9069
	5POD	0.036±0.011	0.049±0.012	0.4553
	7POD	0.031±0.007	0.044±0.007	0.249
mGPS	Presurgery	1/7	1/6	0.9057
	1POD	7/7	4/6	0.0605
	3POD	7/7	6/6	Uncalculated
	5POD	6/7	5/6	0.9057
	7POD	4/7	6/6	0.0342

WBC, white blood cell; CRP, C-reactive protein; CK, creatine kinase; Alb, albumin; N/L, neutrophil/lymphocyte ratio; Platelet/Lymph, platelet/lymphocyte ratio; mGPS score, 0 = CRP ≤ 0.5 and Alb ≥ 3.5, 1,2 = CRP > 0.5 and/or Alb < 3.5, POD, postoperative day.

day in the M-method group was significantly lower than that of the conventional group (average 4/7 vs. 6/6, $p = 0.0342$). No significant differences were observed between the M- and conventional-method groups in other variables (Table 3).

Discussion

IPAA is the main surgical procedure for UC. We searched PubMed and ScienceDirect for papers describing in detail the order of blood vessel ligating in IPAA surgery

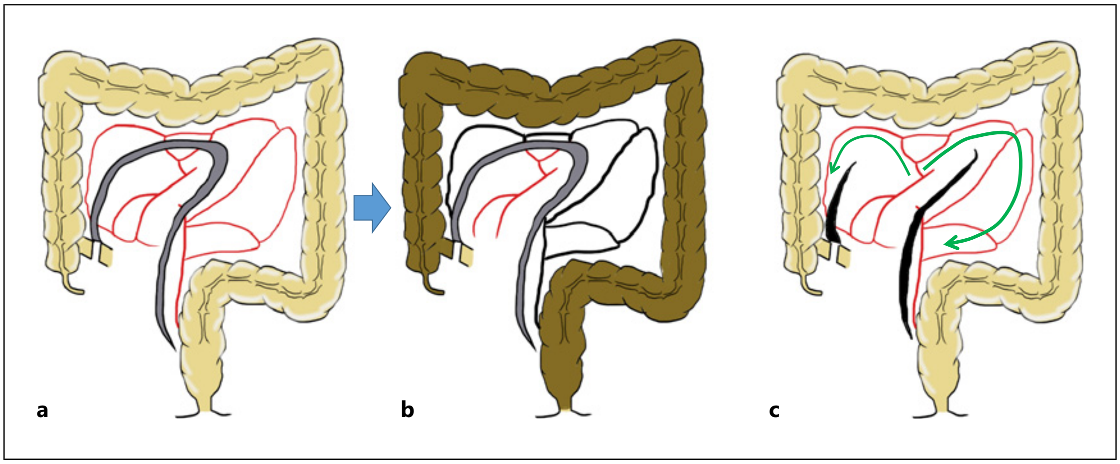

Fig. 2. Comparison of early and late ligation of the middle colic artery (MCA). When the main vessels are ligated at an early time point (**a**), ischemia of the colon occurs at an early time point (**b**). Late ligation of the MCA might avoid ischemia because the blood from the MCA flows throughout the colon (**c**).

and found no report indicating the importance of sparing the middle colic artery. Since it takes a relatively long time to perform an IPAA, intestinal ischemia may occur if the main blood vessels are ligated at an early stage of the surgery (Fig. 2a). Conventionally, we had ligated blood vessels at an early stage of the IPAA, and some of the resected specimens exhibited a dark purple color that resembles ischemia (Fig. 2b). Without ligation of the middle colic artery, the blood in this vessel is thought to flow widely through the colon. A late dissection of the middle colic artery is thus speculated to avoid ischemia (Fig. 2c).

Strangulation obstruction causes intestinal ischemia, leading to shock or death [9]. Intestinal ischemia should thus be avoided as much as possible. Many variables associated with intestinal ischemia have been investigated; for example, base excess, lactate, hemoglobin, leukocytes, thrombocytes, CRP, CK, pH, LDH, and the neutrophil/lymphocyte ratio [10, 11]. We examined eight of these (Table 3).

Surgery for colorectal cancer usually does not cause ischemia because intestinal blood flow is maintained until the resection. For example, even after ligation of the inferior mesenteric artery, blood from the middle colic artery is flowing in the marginal artery of the left-side colorectum in a low anterior resection or sigmoidectomy. However, since an IPAA resects the whole colon and rectum, if the blood flow is interrupted early, the colon could undergo ischemia and the ischemia time would be long.

Although the number of cases in the present study was small ($n = 13$), our analyses revealed differences between the conventional method and M-method in the rate of complications and the postoperative hospital stay, and differences in albumin and the mGPS were also observed. mGPS is reported to be developed as an objective tool to grade state of inflammation and associated with postoperative complications in IBD patients undergoing elective bowel resection [12]. Our results were consistent with that report. In addition, the surgical morbidity including bowel obstruction might be involved in these data differences and extended hospital stays. The differences between the two methods may become clearer if some new data reflecting ischemia are discovered and measured.

In a study using indocyanine green dye, the anal canal stump was well-dyed by indocyanine green before the middle colic artery was ligated, which means that blood from the middle colic artery was flowing well through the anal canal (figure not shown). Ligating the middle colic artery immediately before resecting the specimen is not troublesome and does not lengthen the operation time. In order to avoid intestinal ischemia, preserving the middle colic artery should be considered as an option.

This study has several limitations. It was a retrospective analysis of cases at a single facility, limiting the analysis of postoperative outcomes. The number of patients was small but will continue to increase as our experience with the M-method grows. Due to the small patient number, the study might have been underpowered, thus showing few significant differences. In addition, the era of each method's use differed, and the level of medical care may have differed. It is thought that in the era of the conventional method, we were not yet proficient in UC surgery. It is quite possible that the M-method at a newer time resulted in better performance due to the learning curve. Even considering these limitations, our findings indicate that the M-method is feasible and has preferable short-term outcomes compared to the conventional method.

Conclusion

Since intestinal ischemia has been reported to have a negative effect on the body, we devised the M-method to minimize the time of colonic ischemia during surgery. Compared to the conventional method, the M-method, which ligates the middle colic artery immediately before removal of the specimen, provided a lower complication rate, a shorter postoperative hospital stay, and better nutritional status. Late ligation of the middle colic artery may be beneficial and can be recommended for IPAAs in patients with UC. However, it is necessary to consider the small number of cases and the uncontrolled historical comparison. It would be premature to conclude that this method is better.

Acknowledgments

We would like to thank KN International (https://www.kninter.co.jp/) for English language editing.

Statement of Ethics

All study protocols were approved by the Ethics Committee of Teikyo University (approval date, August 23, 2016, registration no. 16-032). All methods were performed in accordance with relevant guidelines and regulations, including the Declaration of Helsinki. Written informed consent was obtained from all patients and relevant persons (such as the parent or legal guardian) to publish the information.

Conflict of Interest Statement

There are no conflicts of interest to declare.

Funding Sources

None of the authors had funding sources relevant to this study.

Author Contributions

Conception and design, drafting the article, data analysis, and interpretation: K. Matsuda and Y. Hashiguchi. Data acquisition: K. Matsuda, Y. Hashiguchi, T. Hayama, K. Hayashi, T. Miyata, K. Asako, Y. Fukushima, R. Shimada, K. Kaneko, and K. Nozawa. Critical revision of the article and final approval of the article: K. Matsuda, Y. Hashiguchi, T. Hayama, K. Hayashi, T. Miyata, K. Asako, Y. Fukushima, R. Shimada, K. Kaneko, K. Nozawa, H. Ochiai, T. Yamamoto. All authors have read and approved the final version of the manuscript, including the authorship list.

Data Availability Statement

The data that support the findings of this study are not publicly available due to privacy reasons but are available from the corresponding author upon reasonable request. Further inquiries can be directed to the corresponding author.

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