Comparison of Laparoscopic and Open Emergency Surgery for Colorectal Perforation: A Retrospective Study

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Research Article

Keywords: colorectal perforation, emergency treatment, laparoscopic surgery, open surgical procedure, retrospective studies

Posted Date: November 11th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-1058924/v1

Abstract

Background

This study aimed to clarify the safety and efficacy of laparoscopic surgery for colorectal perforation by comparing the clinical outcomes between laparoscopic and open emergency surgery for colorectal perforation.

Methods

We retrospectively reviewed the data of 100 patients who underwent surgery for colorectal perforation. The patients were categorized into two groups: the open group included patients who underwent laparotomy, and the laparoscopic group included those who underwent laparoscopic surgery. Clinical and operative characteristics and postoperative outcomes were evaluated.

Results

The open and laparoscopic groups included 58 and 42 patients, respectively. More than half of the patients in both groups developed perforation in the sigmoid colon (open, 55.2%; laparoscopic, 59.5%). The most common cause of perforation was diverticulum, followed by colorectal cancer. The mean intraoperative blood loss tended to be lower in the laparoscopic group than in the open group (78.8 mL versus 160.1 mL; *P*=0.0756). Hospital stay tended to be shorter in the laparoscopic group than in the open group (42.5 versus 55.7 days; *P*=0.0965). There were no significant differences in either the short- or long-term outcomes between the two groups. Univariate and multivariate analyses showed that the choice of surgical approach (open versus laparoscopic) did not affect overall survival in patients with colorectal perforation.

Conclusions

The laparoscopic approach for colorectal perforation in an emergency setting is a safe procedure compared with the open approach. The laparoscopic approach was associated with a decrease in intraoperative blood loss and a shorter length of hospital stay.

Background

In recent years, the usefulness and safety of laparoscopic surgery have been demonstrated in various abdominal surgical procedures, such as cholecystectomy, gastrectomy, and colectomy [1–6]. Regarding colorectal diseases, several studies have compared open and laparoscopic surgery under various conditions, such as total colectomy for acute colitis, surgery for colorectal cancers, and colectomy for inflammatory bowel diseases [5–11]. These studies suggest that the advantages of laparoscopic surgery

include earlier recovery of bowel function, a lower incidence rate of postoperative complications, reduced pain scores, decreased estimated blood loss, and shorter hospital stay [6–9]. However, there are few studies on the efficacy of laparoscopic surgery in an emergency setting. A previous comparative study that examined the laparoscopic approach for emergency colorectal diseases was designed for patients with complicated diverticular disease [12], and another study targeted patients who underwent colectomy regardless of the primary diagnosis [13]. However, data are limited, and the role of the laparoscopic approach under emergency conditions remains controversial. Furthermore, the studies included patients with various conditions, such as colorectal obstruction, hemorrhage, fistula, and perforation [12, 13].

Therefore, this study focused on colorectal perforation, which can lead to high morbidity and mortality and often causes generalized peritonitis and septic shock. We aimed to clarify the safety and efficacy of laparoscopic surgery for colorectal perforation by comparing the clinical outcomes between laparoscopic and open emergency surgery for colorectal perforation.

Methods

Patients

In this retrospective cohort study, we reviewed the data of 372 patients who underwent emergency surgery for abdominal perforation peritonitis at our single institute between August 2010 and December 2019. One hundred patients who underwent open or laparoscopic surgery who were diagnosed with colorectal perforation were eligible for analysis. A total of 272 patients diagnosed with upper gastrointestinal perforation, perforation of the jejunum and ileum, perforation of the appendix, or postoperative anastomotic leakage were excluded. Patients were categorized into the open and laparoscopic groups according to the surgical approach used. Cases in which the initial laparoscopic approach was converted to the open laparotomy approach, according to intraoperative judgment, were included in the open group.

Moreover, 100 patients were categorized into the cancer group and non-cancer group based on the presence of cancer lesions at the time of perforation. In each group, the abovementioned analyses were performed.

Permission to perform this study was provided by the Institutional Review Board of the National Kyushu Medical Center (20C033). All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and later versions. Informed consent to be included in the study or equivalent was obtained from all patients.

Statistical analyses

Differences in characteristics between the groups were evaluated using Fisher's exact test or an unpaired *t*-test. Survival curves were plotted according to the Kaplan–Meier method, and differences were analyzed

using a log-rank test. Univariate and multivariate analyses were performed using a Cox proportional hazards model to identify independent prognostic factors. All *P*-values were two-sided, and *P*-value <0.05 was considered statistically significant. All analyses were performed using JMP PRO 11 software (SAS Institute Inc., https://www.jmp.com/ja_jp/home.html).

Results

Patient characteristics

Patients were categorized into two groups (58 patients in the open group and 42 in the laparoscopic group) according to the surgical approach used. Baseline demographic and clinical features of patients in the open and laparoscopic groups are summarized in Table 1. There were no significant differences in age, sex, location, and causes of perforation between the two groups. More than half of the patients in both groups developed perforation in the sigmoid colon (open, 55.2%; laparoscopic, 59.5%). The incidence of rectal perforation was higher in the laparoscopic group than in the open group (23.8% versus 15.5%). Diverticulum was the most frequent cause of perforation, with 29.3% in the open group and 28.6% in the laparoscopic group, followed by colorectal cancer, with 27.6% and 23.8% in the open and laparoscopic groups, respectively.

Table 1
Baseline demographic and clinical features of the open and laparoscopic groups

WBC (μl)	**Mean (range)**	**8815±901 (1300-33200)**	**9542±803 (2000-22000)**	**0.5652**
Factor		**Open group (n = 58) n (%)**	**Laparoscopic group (n = 42) n (%)**	***P*-value**
Sex	Male	29 (50.0)	20 (47.6)	0.8418
	Female	29 (50.0)	22 (52.4)	
Age, years	Mean	71.7±1.5	72.1±2.1	0.8766
	(range)	(41-91)	(26-95)	
Location	C	4 (6.9)	1 (2.4)	
	A	4 (6.9)	2 (4.8)	
	T	5 (8.6)	3 (7.1)	
	D	4 (6.9)	1 (2.4)	
	S	32 (55.2)	25 (59.5)	
	R	9 (15.5)	10 (23.8)	
Side of the perforation site	Right	13 (22.4)	6 (14.3)	0.4393
	Left	45 (77.6)	36 (85.7)	
CRP (mg/dl)	Mean	14.2±1.7	11.5±1.8	0.2872
	(range)	(0.07-47.17)	(0.05-40.0)	
Albumin (g/dl)	Mean	2.7±0.1	2.9±0.1	0.2479
	(range)	(1.5-3.9)	(1.3-4.5)	

Data are presented as the number (%) unless otherwise stated. C, Cecum; A, Ascending colon; T, transverse colon; D, descending colon; S, sigmoid colon; R, rectum; WBC, white blood cell; CRP, C-reactive protein; ESD, endoscopic submucosal dissection; EMR, endoscopic mucosal resection.

WBC (μl)	**Mean (range)**	**8815±901 (1300-33200)**	**9542±803 (2000-22000)**	**0.5652**
Perforation causes	Diverticulum	17 (29.3)	12 (28.6)	
	Cancer	16 (27.6)	10 (23.8)	
	Post-ESD or EMR	4 (6.9)	2 (4.8)	
	Steroid	2 (3.5)	2 (4.8)	
	Fecal	0 (0.0)	2 (4.8)	
	Others	11 (19.0)	5 (11.9)	
	Unknown	8 (13.8)	9 (21.4)	

Data are presented as the number (%) unless otherwise stated. C, Cecum; A, Ascending colon; T, transverse colon; D, descending colon; S, sigmoid colon; R, rectum; WBC, white blood cell; CRP, C-reactive protein; ESD, endoscopic submucosal dissection; EMR, endoscopic mucosal resection.

Operative outcomes

Operative outcomes were compared between the open and laparoscopic groups and are summarized in Table 2. There were no significant differences in the mean operative times (open, 145 min versus laparoscopic, 148 min; *P*=0.8148) and occurrence of postoperative complications (open, 56.9% versus laparoscopic, 45.2%; *P*=0.3117) between the two groups. Intraoperative blood loss was 78.8 mL and 160.1 mL (*P*=0.0756) and hospital stay was 42.5 and 55.7 days (*P*=0.0965) in the laparoscopic and open groups, respectively. Regarding postoperative complications, the occurrence of surgical site infection (12.1% versus 2.4%, *P*=0.1338) and abdominal abscess (12.1% versus 7.1%, *P*=0.5131) was higher in the open group than in the laparoscopic group; however, the difference was not significant. Regarding prognosis, there were no significant differences in mortality within 30 days after surgery, hospital mortality, and median survival time (MST) between the two groups (Table 2).

Table 2
Comparison of operative outcomes between the open and laparoscopic groups

Intra-abdominal abscess	**No**	**51 (87.9)**	**39 (92.9)**	**0.5131**
	Yes	**7 (12.1)**	**3 (7.1)**	
Factor		**Open group (n = 58) n (%)**	**Laparoscopic group (n = 42) n (%)**	***P*-value**
Surgical procedure	Stoma	23 (39.7)	25 (59.5)	
	Resection+anastomosis	5 (8.6)	1 (2.4)	
	Resection+anastomosis+stoma	3 (5.2)	1 (2.4)	
	Resection+stoma	26 (44.8)	14 (33.3)	
	Others	1 (1.7)	1 (2.4)	
Operative time (min)	Mean	145.5±6.4	148.0±9.3	0.8148
	(range)	(35-267)	(48-298)	
Intraoperative blood loss (ml)	Mean	160.1±33.8	78.8±25.4	0.0756
	(range)	(0-1210)	(0-866)	
Postoperative complication	No	25 (43.1)	23 (54.8)	0.3117
	Yes	33 (56.9)	19 (45.2)	
Surgical site infection	No	51 (87.9)	41 (97.6)	0.1338
	Yes	7 (12.1)	1 (2.4)	
Ileus	No	55 (94.8)	36 (85.7)	0.1603
	Yes	3 (5.2)	6 (14.3)	
CD grade ≥3a	<3a	44 (75.9)	33 (78.6)	0.8133
	≥3a	14 (24.1)	9 (21.4)	
Hospital stay (days)	Mean	55.7±5.5	42.5±5.2	0.0965
	(range)	(1-232)	(7-143)	
Prognosis	Survival	32 (55.2)	21 (50.0)	0.6864
	Death	26 (44.8)	21 (50.0)	

Data are presented as the number (%) unless otherwise stated. CD, Clavien–Dindo classification.

Intra-abdominal abscess	**No**	**51 (87.9)**	**39 (92.9)**	**0.5131**
	Yes	**7 (12.1)**	**3 (7.1)**	
Mortality within 30 days after surgery	Survival	51 (87.9)	37 (88.1)	1.0000
	Death	7 (12.1)	5 (11.9)	
Hospital mortality	Survival	46 (79.3)	36 (85.7)	0.4440
	Death	12 (20.7)	6 (14.3)	
Median survival time (days)		1313	653	0.5630
Data are presented as the number (%) unless otherwise stated. CD, Clavien–Dindo classification.				

Postoperative survival

The Kaplan–Meier method was used to analyze the overall survival (OS) and to compare the postoperative prognosis between the open and laparoscopic groups (Fig. 1). Although the MSTs of the open and laparoscopic groups were 1313 and 653 days, respectively, 1-year OS rates were 62.0% and 69.2%, respectively. There were no significant differences in 1-year OS rates between the two groups (P=0.5630). Comparing the prognosis according to the cause of perforation, patients with cancer at surgery had a significantly worse prognosis than patients with other diseases (1-year OS, 38.0% versus 73.9%, MST, 205 versus 1590 days; P=0.0002) (Fig. 2). The survival data between open and laparoscopic surgery were compared for patients with cancer and those with other diseases. There were no significant differences in 1-year OS rates between the two groups (Fig. 3).

Predictive factors for postoperative survival

Univariate and multivariate analyses showed that the occurrence of postoperative complications (P=0.0075 and 0.0141, respectively) and cancer (versus other diseases) (P=0.0006 and 0.0011, respectively) were independent predictive factors for poorer 1-year OS rates in patients with colorectal perforation. The surgical approach taken (open versus laparoscopic) was not associated with differences in 1-year OS rates in patients with colorectal perforation in both univariate and multivariate analyses (Table 3).

Table 3
Univariate and multivariate analyses for overall survival

Factor	Univariate analysis		Multivariate analysis	
	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value
Female (vs. Male)	1.016 (0.570-1.824)	0.9561	1.036 (0.561-1.921)	0.9110
Age < 75 y (vs. ≥ 75 y)	1.431 (0.800-2.553)	0.2245	1.360 (0.752-2.453)	0.3062
Right side of the colon (vs. left side)	1.112 (0.522-2.154)	0.7693	1.189 (0.543-2.392)	0.6476
Postoperative complication	2.225 (1.236-4.116)	0.0075	2.131 (1.164-3.999)	0.0141
Cancer (vs. other diseases)	2.981 (1.625-5.353)	0.0006	2.860 (1.540-5.223)	0.0011
Laparoscopic (vs. open)	1.187 (0.658-2.118)	0.5649	1.270 (0.696-2.291)	0.4312
CI, confidence interval; HR, hazard ratio				

Discussion

This study demonstrated that laparoscopic surgery for colorectal perforation tended to be associated with a reduced amount of intraoperative blood loss and a shorter length of hospital stay. The operative outcomes indicated that the laparoscopic approach could be performed safely in emergency surgery for colorectal perforation with accurate decision-making regarding the indications.

Several studies have compared outcomes between open and laparoscopic approaches for various diseases and conditions [1–13]. Siletz et al. have suggested that laparoscopic surgery is associated with reduced complication rates, shorter operative times, shorter lengths of stay, and lower rates of discharge to skilled nursing facilities for various abdominal conditions, such as gastric perforation, small bowel disease, and ventral hernia [14]. Despite this, Cocorullo et al. have indicated that, for the elderly population, there are no differences in operation times, morbidity rates, and mortality rates between patients undergoing open and laparoscopic approaches for abdominal emergencies, including gastro-duodenal ulcer, small bowel disease, colonic acute disease, cholecystitis, and appendicitis [15]. Thus, these studies demonstrate that the laparoscopic approach can be safely performed even for emergency abdominal surgery [14, 15].

Focusing on the previous reports related to surgery for colorectal disease in the emergency setting, Turley et al. compared laparoscopic and open Hartmann procedures for the emergency treatment of diverticulitis and demonstrated that the laparoscopic approach results in fewer overall complications and a shorter mean length of hospitalization; however, it does not decrease morbidity or mortality [16]. Koh et al. compared the outcomes of laparoscopic colectomies with those of open colectomies under emergency

conditions, such as colorectal bleeding, obstruction, and perforation, and demonstrated that the operative times in laparoscopic colectomies were longer than those in open colectomies, while the duration of hospitalization and postoperative morbidity between the two groups were similar [13]. Letarte et al. compared the perioperative outcomes of laparoscopic colon resection and open colon resection for the treatment of complicated diverticular disease in the emergency setting, and they suggested that laparoscopic surgery was associated with decreased morbidity, intraoperative blood loss, time to oral intake, and length of hospital stay, while the mean operative time was longer than that of the open approach [12].

The above studies targeted colorectal disease with indications for emergency surgery, and they included various conditions, such as perforation, hemorrhage, and obstruction. The differences among these conditions are important and may substantially affect surgical procedures or perioperative outcomes. Notably, colorectal perforation has an extremely poor prognosis due to generalized peritonitis and sepsis, and it often requires extensive drainage. Therefore, this study only focused on colorectal perforation. Our findings on intraoperative blood loss and hospital stay were similar to those reported previously. Most previous studies have demonstrated that the laparoscopic approach requires longer operative times [12, 13], whereas our study showed that the mean operative times were not different between the open and laparoscopic groups. This finding might be related to the patients in our study, who had all received a diagnosis of colorectal perforation and who were usually in poor general condition and required urgent surgery. Consequently, decisions to convert to open surgery for patients in whom it was difficult to complete laparoscopic surgery may have been made faster than for those with other diseases.

This study focused on the causes of colorectal perforation, i.e., malignant or benign diseases, because they might affect the prognosis. Indeed, there were significant differences in the prognoses of patients with and without cancer. Moreover, in patients with cancer, progression of the primary cancer may be associated with their prognoses. In this study, both the cancer and other disease groups demonstrated no significant differences in 1-year OS rates between the open and laparoscopic approaches.

This study had a few limitations. A main limitation of our study was selection bias. The surgical procedure chosen, namely, an open or a laparoscopic approach, was dependent on each surgeon's decision. Consequently, surgeons who are proficient in laparoscopic surgery may tend to select the laparoscopic approach for wider indications, and choices of the surgeons may affect surgical and postoperative outcomes. In addition, this was a single-institution retrospective study that included a small sample size. Patients in this study were diagnosed with colorectal perforation and underwent emergency surgery; therefore, it was impossible to avoid selection bias or to design a prospective study. A comparison of the findings obtained from retrospective studies from various institutes would be meaningful. The findings from the current study may provide useful information regarding the clinical value of the laparoscopic approach for colorectal perforation in an emergency setting.

Conclusions

The laparoscopic approach for colorectal perforation in an emergency setting is a safe procedure when conducted after careful patient selection, and it may decrease intraoperative blood loss and shorten the length of hospital stay.

Abbreviations

OS, overall survival

MST, median survival time

Declarations

Ethics approval and consent to participate: Permission to perform this study was provided by the Institutional Review Board of the National Kyushu Medical Center (20C033). Informed consent to be included in the study or equivalent was obtained from all patients. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and later versions. Informed consent to be included in the study or equivalent was obtained from all patients.

Consent for publication

Not Applicable

Availability of data and material: The data are available upon reasonable request by contacting the corresponding author.

Conflicts of interest/Competing interests: Dr. Kensuke Kudou was supported by grants from the Kaibara Morikazu Medical Science Promotion Foundation in 2019, the Uehara Memorial Foundation in 2020, Grant of The Clinical Research Promotion Foundation in 2020 and Fukuoka Public Health Promotion Organization Cancer Research Fund in 2021. Drs. Tetsuya Kusumoto, Yuho Ebata, Sho Nambara, Yasuo Tsuda, Eiji Kusumoto, Rintaro Yoshida, Yoshihisa Sakaguchi, and Koji Ikejiri have no conflicts of interest or financial ties to disclose.

Funding: Dr. Kensuke Kudou was supported by grants from the Kaibara Morikazu Medical Science Promotion Foundation in 2019, the Uehara Memorial Foundation in 2020, Grant of The Clinical Research Promotion Foundation in 2020 and Fukuoka Public Health Promotion Organization Cancer Research Fund in 2021. The funding bodies played no role in the design of the study and collection, analysis, and interpretation of data and in writing the manuscript.

Authors' contributions:

K.K. designed the study. K.K., E.K., S.N., Y.T., and R.Y. acquired the data.

Analysis and interpretation of data: K.K., E.K., and Y.S. analyzed the data. K.K. performed statistical analyses. K.K. and T.K. drafted the article. T.K., and Y.S. revised the article critically for important intellectual content. T.K., Y.S., and K.I. approved the final version of manuscript. All authors have read and approved the manuscript.

Acknowledgments: We thank the Kaibara Morikazu Medical Science Promotion Foundation and Fukuoka Public Health Promotion Organization Cancer Research Fund for financial support. We thank Editage (https://www.editage.jp/) for language editing.

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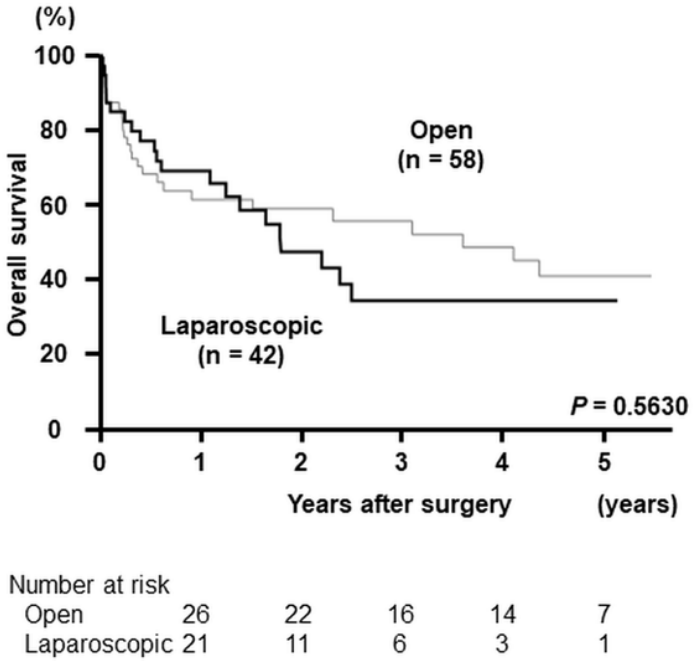
Figures

Figure 1

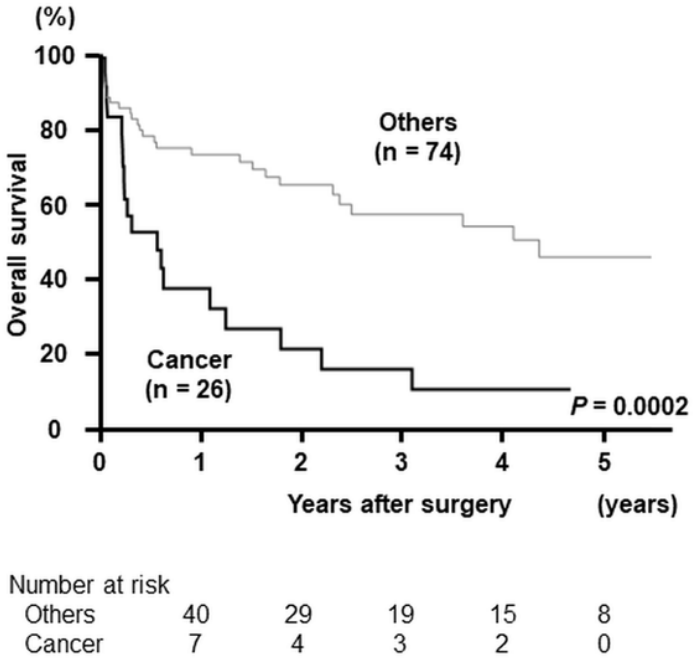


	1 year OS	MST (days)
Open	62.0%	1313
Laparoscopic	69.6%	653

Figure 1

Postoperative survival in patients with colorectal perforation based on surgical approach, including a comparison between the laparoscopic and open approaches. The 1-year overall survival rates and median survival time in the two groups are shown in the table. OS, overall survival; MST, median survival time

Figure 2

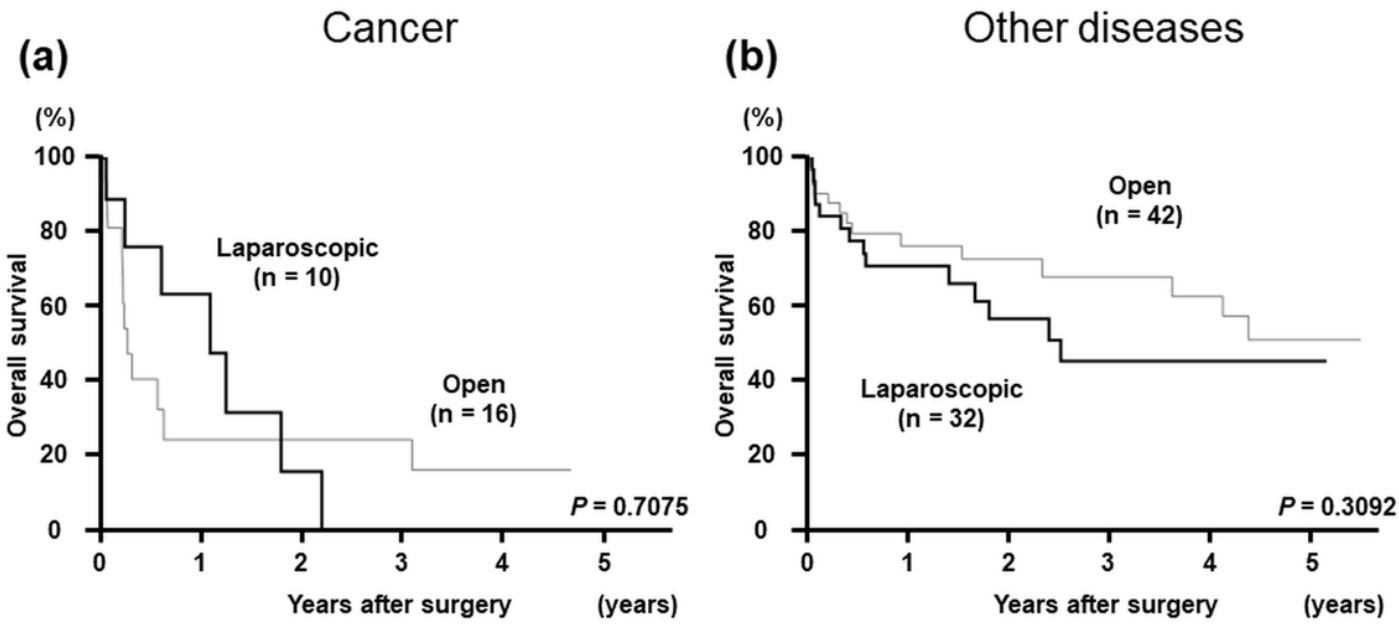


	1 year OS	MST (days)
Others	73.9%	1590
Cancer	38.0%	205

Figure 2

Postoperative survival in patients with colorectal perforation based on the causes of the perforation, including a comparison between cancer and other diseases. The 1-year overall survival rates and median survival time in the two groups are shown in the table. OS, overall survival; MST, median survival time

Figure 3



Number at risk

Open	3	3	3	2	0
Laparoscopic	4	1	0	0	0

	1 year OS	MST (days)
Open	24.4%	96
Laparoscopic	63.5%	396

Number at risk

Open	23	19	13	12	7
Laparoscopic	17	10	6	3	1

	1 year OS	MST (days)
Open	76.4%	-
Laparoscopic	71.0%	909

Figure 3

Postoperative survival in patients with colorectal perforation based on surgical approach, including a comparison between the laparoscopic and open approaches after categorizing the patients into (a) cancer and (b) other disease groups according to the causes of perforation. The 1-year overall survival rates and median survival time in the two groups are shown in the table. OS, overall survival; MST, median survival time