Received: 29 September 2021 | Revised: 16 November 2021 | Accepted: 28 November 2021

DOI: 10.1002/ags3.12533

AGSurg Annals of Gastroenterological Surgery Open Access WILEY

ORIGINAL ARTICLE

Laparoscopic Surgery for Acute Diffuse Peritonitis Due to Gastrointestinal Perforation: A Nationwide Epidemiologic Study Using the National Clinical Database

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Funding information
The Japanese Society for Abdominal Emergency Medicine

Abstract

Background: Elective laparoscopic surgery is now widely accepted in the treatment of abdominal diseases because of its minimal invasiveness and rapid postoperative recovery. It is also used in the emergency setting for the diagnosis and treatment of acute diffuse peritonitis regardless of the causative disease. However, the value of laparoscopy in acute diffuse peritonitis remains unclear. In this study we aimed to show trends in the use of laparoscopy over time and compare the real-world performance of laparoscopic surgery with that of open surgery for acute diffuse peritonitis due to gastrointestinal perforation.

Methods: We extracted data from the National Clinical Database, a nationwide surgery registration system in Japan, for patients with a diagnosis of acute diffuse peritonitis due to gastroduodenal or colorectal perforation between 2016 and 2019. Trends in the use of laparoscopy over time were identified. Patient characteristics, laboratory findings, surgical findings, and postoperative complications were compared between laparoscopic surgery and open surgery.

Results: Patients in poor condition and those with abnormal laboratory findings tended to undergo open surgery. Anesthesia time and operating time were longer for laparoscopic surgery in patients with gastroduodenal perforation but shorter in those with colorectal perforation. Fewer complications occurred in patients who underwent laparoscopic surgery. The number of institutions where laparoscopic surgery was performed and the proportion of the use of laparoscopy at each institution increased over time.

Conclusion: The use of laparoscopy is becoming common in surgery for acute diffuse peritonitis due to gastrointestinal perforation. This approach may be a useful option for acute diffuse peritonitis.

KEYWORDS
emergency surgery, gastrointestinal perforation, laparoscopic surgery, peritonitis

1 | INTRODUCTION

Elective laparoscopic surgery is now widely performed for both benign and malignant disease because it is less invasive than open surgery and postoperative recovery is more rapid.[1-3] Laparoscopy has been reported to be useful in various surgical procedures, including gastrectomy and colectomy.[4-7] However, its usefulness in the emergency setting is still unclear. Laparoscopic surgery requires an experienced surgeon, a patient in stable condition, and appropriate equipment, not all of which are possible when emergency surgery is required.[8-11]

Acute diffuse peritonitis is a critical condition that warrants emergency surgery regardless of the causative disease, which is often gastrointestinal perforation. Although laparoscopic surgery would not alter the outcome of acute diffuse peritonitis, its minimal invasiveness might aid the patient's ability to recover in the emergency setting if they are stable enough to tolerate it.[12-14] Acute diffuse peritonitis is a common critical disease, but the number of patients treated with the disease at a given institution is limited. Therefore, in this study we aimed to demonstrate trends in the use of the laparoscopy over time and compare the real-world performance of laparoscopic surgery with that of open surgery in patients with acute diffuse peritonitis due to gastroduodenal or colorectal perforation using a nationwide surgical database in Japan.

2 | PATIENTS AND METHODS

2.1 | Study design and setting

This retrospective observational study was performed using data from the National Clinical Database (NCD). The NCD is a nationwide surgical registration system in Japan that is linked to the Japanese Society of Gastrointestinal Surgery board certification system and covers almost all surgical cases in Japan.[15-17] The database contains detailed data for patients with acute diffuse peritonitis, including demographic characteristics, laboratory findings, surgical findings, and postoperative complications. Several reports on emergency surgery have been published using data from the NCD.[18-20]

We extracted data from this database for patients aged ≥18 y who underwent surgery for acute diffuse peritonitis due to gastroduodenal or colorectal perforation between 2016 and 2019. The study was approved by the Ethics Committee of Kyoto University (approval number R2777).

2.2 | Statistical analysis

Categorical variables are shown as the number and percentage and continuous variables as the median and interquartile range. Patient characteristics, laboratory findings, surgical findings, postoperative complications, and time trends were compared between patients with gastroduodenal or colorectal perforation according to whether they were treated by laparoscopic surgery or open surgery.

3 | RESULTS

3.1 | Gastroduodenal perforation

3.1.1 | Patient characteristics

In total, 7898 patients (71.9%) with gastroduodenal perforation underwent open surgery for acute diffuse peritonitis and 3094 (28.1%) underwent laparoscopic surgery during the study period. The patient characteristics are shown in Table 1. There were fewer elderly patients and women in the laparoscopy surgery group than in the open surgery group. The proportion of elderly patients increased year by year in both groups. Body mass index was similar between the two groups. Laparoscopic surgery was performed less often in patients with diabetes or dyspnea, those who were not independent in activities of daily living, those requiring a ventilator, and those with chronic obstructive pulmonary disease, pneumonia, hypertension, history of myocardial infarction, angina, acute renal failure, dialysis, history of cerebral infarction, bleeding tendency, or sepsis.

3.1.2 | Laboratory findings

Laboratory findings in patients who underwent surgery for acute diffuse peritonitis are summarized in Table S1. Patients who underwent open surgery tended to have abnormal values, including a markedly low white blood cell count (WBC; <3500/μL), low hemoglobin (Hb; male, <13.5 g/dL; female, <11.5 g/dL) low platelets (Plt; <150,000/μL), low albumin (<4.0 g/dL), high blood urea nitrogen (BUN; >20 mg/dL), high creatinine (Cr; >1 mg/dL), high C-reactive protein (CRP; >10 mg/dL), high activated partial thromboplastin time (APTT; >40 sec), and high prothrombin time-international normalized ratio (PT-INR; >1.1).

3.1.3 | Surgical findings

Surgical findings in patients who underwent surgery for acute diffuse peritonitis caused by gastroduodenal perforation are summarized in Table 2. Anesthesia time and operating time were longer in the laparoscopic surgery group than in the open surgery group. Estimated blood loss and transfusion requirements were smaller and the length of hospital stay was shorter in the laparoscopic surgery group. The proportion of patients who underwent concurrent surgery with abdominal drainage was similar between the laparoscopic surgery group and open surgery group (Table 2). Surgical findings in 2016 were similar to those in 2019.

TABLE 1 Demographic and clinical characteristics of patients with gastroduodenal perforation

	Open								Laparoscopy							
	2016		2017		2018		2019		2016		2017		2018		2019	
	n = 1925		n = 1905		n = 2042		n = 2026		n = 649		n = 704		n = 855		n = 886	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Age (y)																
<70	990	51.4	939	49.3	958	46.9	943	46.5	436	67.2	455	64.6	551	64.4	510	57.6
≥70	935	48.6	966	50.7	1084	53.1	1083	53.5	213	32.8	249	35.4	304	35.6	376	42.4
Sex																
Male	1279	66.4	1227	64.4	1318	64.5	1298	64.1	465	71.6	509	72.3	604	70.6	630	71.1
Female	646	33.6	678	35.6	724	35.5	728	35.9	184	28.4	195	27.7	251	29.4	256	28.9
Body mass index																
<18.5	494	25.7	523	27.5	548	26.8	554	27.3	159	24.5	159	22.6	190	22.2	209	23.6
≥18.5, <25	1175	61.0	1117	58.6	1203	58.9	1199	59.2	413	63.6	446	63.4	537	62.8	554	62.5
≥25	250	13.0	261	13.7	268	13.1	262	12.9	76	11.7	96	13.6	115	13.5	118	13.3
Unknown	6	0.3	4	0.2	23	1.1	11	0.5	1	0.2	3	0.4	13	1.5	5	0.6
Diabetes mellitus																
+	298	15.5	323	17.0	343	16.8	311	15.4	80	12.3	87	12.4	118	13.8	124	14.0
Smoking																
+	642	33.4	610	32.0	631	30.9	655	32.3	287	44.2	315	44.7	357	41.8	374	42.2
Habitual alcohol consumption																
+	506	26.3	491	25.8	565	27.7	515	25.4	204	31.4	215	30.5	263	30.8	284	32.1
Dyspnea																
+	130	6.8	98	5.1	105	5.1	113	5.6	16	2.5	24	3.4	20	2.3	24	2.7
Independence in ADL																
+	540	28.1	494	25.9	571	28.0	544	26.9	117	18.0	162	23.0	178	20.8	187	21.1
Mechanical ventilation																
+	64	3.3	69	3.6	63	3.1	58	2.9	4	0.6	6	0.9	6	0.7	8	0.9
COPD																
+	62	3.2	65	3.4	63	3.1	75	3.7	16	2.5	21	3.0	19	2.2	18	2.0
Pneumonia																
+	64	3.3	51	2.7	42	2.1	44	2.2	9	1.4	5	0.7	11	1.3	15	1.7
Ascites																

TABLE 1 (Continued)

	Open								Laparoscopy							
	2016		2017		2018		2019		2016		2017		2018		2019	
	n = 1925		n = 1905		n = 2042		n = 2026		n = 649		n = 704		n = 855		n = 886	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
+	502	26.1	431	22.6	467	22.9	436	21.5	171	26.3	180	25.6	219	25.6	206	23.3
Hypertension																
+	634	32.9	635	33.3	697	34.1	651	32.1	158	24.3	198	28.1	222	26.0	279	31.5
Congestive heart failure																
+	39	2.0	32	1.7	39	1.9	33	1.6	6	0.9	12	1.7	9	1.1	6	0.7
History of CI																
+	15	0.8	9	0.5	7	0.3	10	0.5	0	0.0	2	0.3	2	0.2	1	0.1
Angina pectoris																
+	25	1.3	13	0.7	14	0.7	16	0.8	2	0.3	4	0.6	5	0.6	3	0.3
Acute renal failure																
+	84	4.4	78	4.1	83	4.1	72	3.6	7	1.1	13	1.8	17	2.0	23	2.6
Dialysis																
+	45	2.3	48	2.5	53	2.6	44	2.2	7	1.1	7	1.0	7	0.8	7	0.8
History of CVD																
+	66	3.4	81	4.3	89	4.4	84	4.1	11	1.7	24	3.4	22	2.6	39	4.4
Long-term steroid use																
+	62	3.2	58	3.0	68	3.3	49	2.4	22	3.4	17	2.4	14	1.6	24	2.7
Risk of hemorrhage																
+	167	8.7	150	7.9	134	6.6	135	6.7	21	3.2	26	3.7	36	4.2	43	4.9
Blood transfusion																
+	82	4.3	80	4.2	101	4.9	89	4.4	18	2.8	12	1.7	10	1.2	16	1.8
Sepsis																
+	147	7.6	164	8.6	301	14.7	279	13.8	16	2.5	15	2.1	52	6.1	54	6.1
Malignancy																
+	154	8.0	141	7.4	145	7.1	126	6.2	20	3.1	23	3.3	25	2.9	30	3.4

Abbreviations: ADL, activities of daily living; CI, cardiac infarction; COPD, chronic obstructive pulmonary disease; CVD, cerebrovascular disease.

TABLE 2 Surgical findings in patients with gastroduodenal perforation

	Open								Laparoscopy							
	2016		2017		2018		2019		2016		2017		2018		2019	
	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR
Anesthesia time, min	150	120–196	150	121–195	151	121–198	150	120–195	156	130–192	158	131–193	160	130–196	157	130–194
Operating time, min	95	70–136	95	71–134	96	71–138	95	70–136	104	83–134	101	80–129	105	79–136	102	79–134
Estimated blood loss, mL	20	2–130	20	3–119	20	4–110	15	2–100	2	0–10	2	0–10	1	0–5	3	0–10
Transfusion, mL	1550	1054–2200	1550	1050–2300	1570	1050–2290	1550	1050–2300	1450	1050–1950	1350	950–1900	1400	950–2000	1350	932–1900
Length of stay, days	20	13–39	21	13–41	20	13–38	20	13–41	13	10–21	14	10–22	13	10–22	14	10–23
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Drainage alone	692	35.9	657	34.5	715	35.0	751	37.1	213	32.8	236	33.5	288	33.7	302	34.1
Drainage with other surgery	1233	64.1	1248	65.5	1327	65.0	1275	62.9	436	67.2	468	66.5	567	66.3	584	65.9

Abbreviation: IQR, interquartile range.

3.1.4 | Postoperative complications

Postoperative complications are summarized in Table 3. Most complications were less common in the laparoscopic surgery group than in the open surgery group, other than rare events such as pulmonary embolism and myocardial infarction. The incidence of sepsis increased year by year in both groups. The incidence of other complications did not change over time. The 30-day mortality was higher in patients with malignancy than in those without malignancy in both groups in 2016. However, the difference between them in 30-day mortality decreased over time in both groups.

3.1.5 | Time trend for the use of laparoscopy

The proportion of patients who underwent laparoscopic surgery for acute diffuse peritonitis due to gastroduodenal perforation increased slightly from 25.2% in 2016 to 30.4% in 2019 (Figure 1). The proportion of institutions performing laparoscopic surgery for acute diffuse peritonitis also increased from 39.3% in 2016 to 46.9% in 2019 (Figure 1). The relationship between number of cases per year and rate of laparoscopic surgery for acute diffuse peritonitis due to gastroduodenal perforation in each hospital is shown in Figure S1.

3.2 | Colorectal perforation

3.2.1 | Patient characteristics

During the study period, 15,545 patients (90.6%) underwent open surgery for acute diffuse peritonitis as a result of colorectal perforation and 1605 (9.4%) underwent laparoscopic surgery. The patient characteristics are shown in Table 4. There were fewer elderly and female patients in the laparoscopy surgery group than in the open surgery group. The proportion of elderly patients increased year by year in both groups. The body mass index was higher in the laparoscopy surgery group. Laparoscopic surgery was performed less often in patients with dyspnea, pneumonia, ascites, hypertension, congestive heart failure, a history of myocardial infarction, angina, acute renal failure, dialysis, history of cerebral infarction, bleeding tendency, or sepsis and in those who required a ventilator or were not independent in activities of daily living.

3.2.2 | Laboratory findings

Laboratory findings for patients who underwent surgery for acute diffuse peritonitis are summarized in Table S2. Patients who underwent open surgery tended to have abnormal values, including a markedly low WBC, low Hb, low Plt, low albumin, high BUN, high Cr,

TABLE 3 Postoperative complications in patients with gastroduodenal perforation

	Open								Laparoscopy							
	2016		2017		2018		2019		2016		2017		2018		2019	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
30-day mortality																
Total	165	8.6	141	7.4	191	9.4	169	8.3	11	1.7	24	3.4	20	2.3	23	2.6
Malignancy	25	16.2	19	13.5	30	20.7	12	9.5	2	10.0	1	4.3	2	8.0	1	3.3
Nonmalignancy	140	7.9	122	6.9	161	8.5	157	8.3	9	1.4	23	3.4	18	2.2	22	2.6
Overall complications																
Grade I	174	9.0	188	9.9	188	9.2	183	9.0	38	5.9	55	7.8	62	7.3	57	6.4
Grade II	335	17.4	299	15.7	335	16.4	319	15.7	66	10.2	78	11.1	97	11.3	96	10.8
Grade III	166	8.6	256	13.4	252	12.3	273	13.5	35	5.4	53	7.5	71	8.3	66	7.4
Grade IV	76	3.9	84	4.4	62	3.0	93	4.6	9	1.4	11	1.6	10	1.2	16	1.8
Grade V	132	6.9	123	6.5	170	8.3	152	7.5	8	1.2	20	2.8	16	1.9	19	2.1
Indications for repeat surgery																
Bleeding	19	1.0	12	0.6	16	0.8	12	0.6	2	0.3	0	0.0	1	0.1	1	0.1
Drainage	59	3.1	61	3.2	45	2.2	60	3.0	12	1.8	11	1.6	9	1.1	12	1.4
Ileus	4	0.2	5	0.3	4	0.2	5	0.2	1	0.2	1	0.1	2	0.2	1	0.1
Other	58	3.0	70	3.7	61	3.0	65	3.2	12	1.8	17	2.4	14	1.6	20	2.3
Superficial incisional SSI																
+	222	11.5	301	15.8	309	15.1	265	13.1	15	2.3	22	3.1	27	3.2	36	4.1
Deep incisional SSI																
+	96	5.0	140	7.3	126	6.2	116	5.7	10	1.5	14	2.0	9	1.1	12	1.4
Organ/Space SSI																
+	159	8.3	184	9.7	208	10.2	187	9.2	24	3.7	39	5.5	37	4.3	42	4.7
Wound disruption																
+	68	3.5	87	4.6	102	5.0	83	4.1	2	0.3	7	1.0	6	0.7	8	0.9
Pneumonia																
+	127	6.6	132	6.9	143	7.0	165	8.1	16	2.5	29	4.1	24	2.8	45	5.1
Unscheduled intratracheal intubation																
+	77	4.0	78	4.1	90	4.4	84	4.1	9	1.4	8	1.1	12	1.4	13	1.5
Pulmonary embolism																
+	5	0.3	3	0.2	8	0.4	5	0.2	1	0.2	2	0.3	3	0.4	0	0.0

(Continues)

TABLE 3 (Continued)

	Open								Laparoscopy							
	2016		2017		2018		2019		2016		2017		2018		2019	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Mechanical ventilation																
+	196	10.2	238	12.5	253	12.4	230	11.4	14	2.2	35	5.0	30	3.5	28	3.2
Renal dysfunction																
+	43	2.2	72	3.8	82	4.0	61	3.0	10	1.5	12	1.7	12	1.4	19	2.1
Acute renal failure																
+	90	4.7	126	6.6	117	5.7	97	4.8	6	0.9	18	2.6	17	2.0	19	2.1
Urinary infection																
+	30	1.6	35	1.8	22	1.1	35	1.7	2	0.3	10	1.4	3	0.4	10	1.1
CNS dysfunction																
+	17	0.9	16	0.8	15	0.7	19	0.9	7	1.1	3	0.4	2	0.2	1	0.1
Cardiac arrest																
+	36	1.9	24	1.3	48	2.4	44	2.2	3	0.5	6	0.9	3	0.4	3	0.3
Myocardial infarction																
+	5	0.3	4	0.2	2	0.1	2	0.1	0	0.0	2	0.3	0	0.0	0	0.0
Blood transfusion																
+	214	11.1	259	13.6	289	14.2	300	14.8	26	4.0	50	7.1	40	4.7	52	5.9
Deep vein thrombosis																
+	15	0.8	18	0.9	23	1.1	27	1.3	2	0.3	5	0.7	6	0.7	1	0.1
Sepsis																
+	118	6.1	175	9.2	276	13.5	261	12.9	10	1.5	18	2.6	38	4.4	34	3.8

Abbreviations: CNS, central nervous system; SSI, surgical site infection.

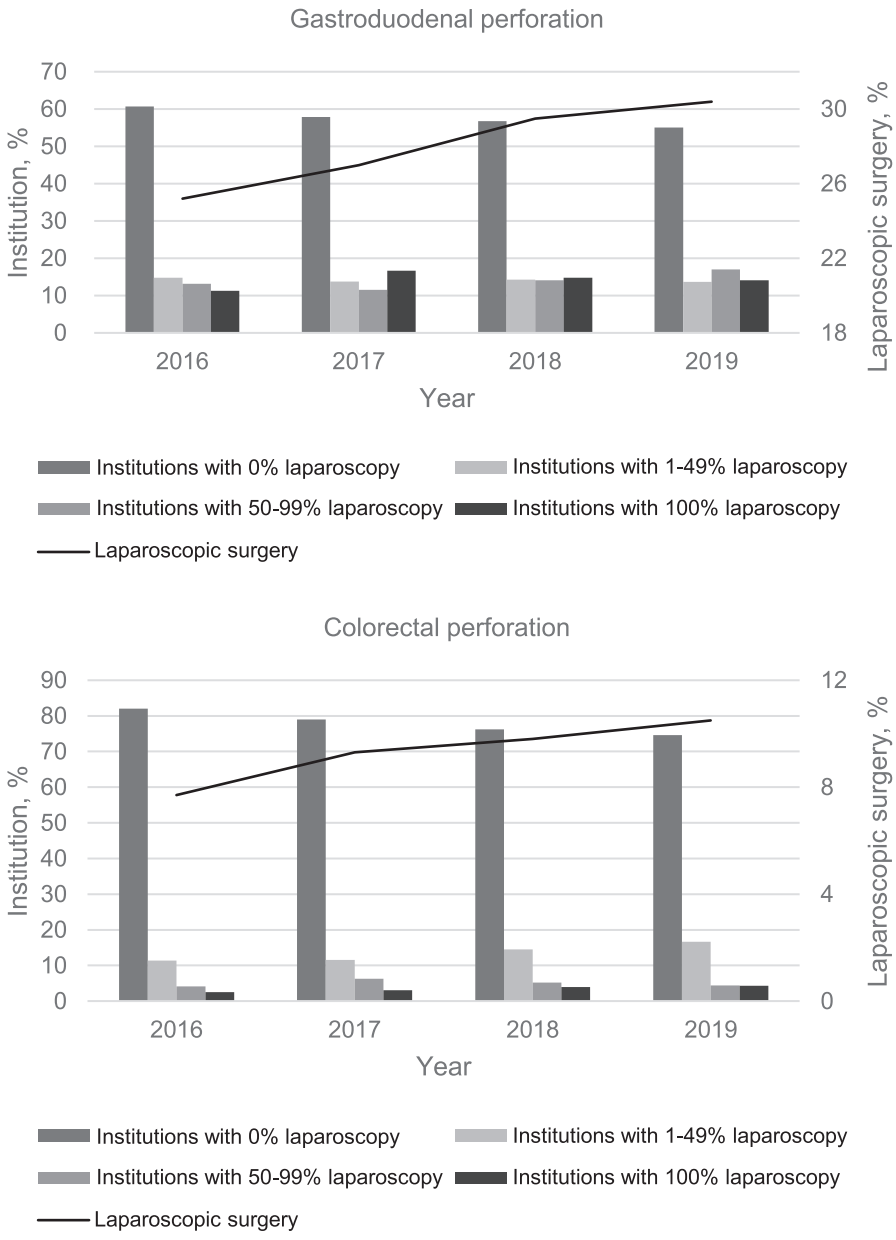

FIGURE 1 Trends in the use of laparoscopy over time. Graph showing the proportions of institutions categorized into four groups (0%, 1%–49%, 50%–99%, and 100%) based on the proportion of laparoscopic surgeries performed for acute diffuse peritonitis at each institution and the proportion of laparoscopic surgery in Japan for this indication between 2016 and 2019

high APTT, and high PT-INR. The proportion of patients with high C-reactive protein was similar between the two groups.

3.2.3 | Surgical findings

Surgical findings in patients who underwent surgery for acute diffuse peritonitis are summarized in Table 5. Anesthesia and operating times were similar between the laparoscopic surgery group and the open surgery group in 2016. The operating time became shorter in the laparoscopic surgery group but remained unchanged in the open surgery group through to 2019. Estimated blood loss and the transfusion requirements were smaller and the length of hospital stay was shorter in the laparoscopic surgery group. The proportion of patients who underwent concurrent surgery with abdominal drainage was higher in the open surgery group than in the laparoscopic surgery group and increased over time in both groups (Table 5).

3.2.4 | Postoperative complications

Postoperative complications are summarized in Table 6. Complications were less common in the laparoscopic surgery group than in the open surgery group. The frequency of infectious complications, such as deep surgical site infection and sepsis, increased year by year in both groups. There was a decrease in the incidence of pneumonia and acute renal failure in the laparoscopic surgery group and increased urinary tract infection, cardiac arrest, and deep vein thrombosis rates in the open surgery group. The 30-day mortality was similar between patients with malignancy and those without malignancy in the open surgery group, while it was higher in patients

TABLE 4 Demographic and clinical characteristics of patients with colorectal perforation

	Open								Laparoscopy							
	2016		2017		2018		2019		2016		2017		2018		2019	
	n = 3720		n = 3782		n = 3826		n = 4217		n = 309		n = 386		n = 416		n = 494	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Age (y)																
<70	1407	37.8	1383	36.6	1353	35.4	1418	33.6	161	52.1	187	48.4	205	49.3	238	48.2
≥70	2313	62.2	2399	63.4	2473	64.6	2799	66.4	148	47.9	199	51.6	211	50.7	256	51.8
Sex																
Male	1966	52.8	1984	52.5	1955	51.1	2203	52.2	202	65.4	222	57.5	237	57.0	292	59.1
Female	1754	47.2	1798	47.5	1871	48.9	2014	47.8	107	34.6	164	42.5	179	43.0	202	40.9
Body mass index																
<18.5	804	21.6	849	22.4	872	22.8	954	22.6	54	17.5	65	16.8	80	19.2	92	18.6
≥18.5, <25	2276	61.2	2260	59.8	2279	59.6	2462	58.4	201	65.0	241	62.4	253	60.8	299	60.5
≥25	619	16.6	656	17.3	659	17.2	768	18.2	54	17.5	80	20.7	83	20.0	103	20.9
Unknown	21	0.6	17	0.4	16	0.4	33	0.8	0	0.0	0	0.0	0	0.0	0	0.0
Diabetes mellitus																
+	524	14.1	557	14.7	534	14.0	651	15.4	44	14.2	68	17.6	64	15.4	74	15.0
Smoking																
+	596	16.0	611	16.2	646	16.9	674	16.0	85	27.5	67	17.4	82	19.7	109	22.1
Habitual alcohol consumption																
+	783	21.0	773	20.4	778	20.3	890	21.1	94	30.4	92	23.8	109	26.2	133	26.9
Dyspnea																
+	225	6.0	207	5.5	177	4.6	199	4.7	14	4.5	11	2.8	11	2.6	12	2.4
Independence in ADL																
+	1092	29.4	1126	29.8	1146	30.0	1232	29.2	66	21.4	87	22.5	80	19.2	94	19.0
Mechanical ventilation																
+	104	2.8	123	3.3	133	3.5	130	3.1	5	1.6	7	1.8	1	0.2	3	0.6
COPD																
+	129	3.5	111	2.9	136	3.6	145	3.4	15	4.9	10	2.6	17	4.1	24	4.9
Pneumonia																
+	85	2.3	89	2.4	76	2.0	103	2.4	5	1.6	4	1.0	3	0.7	7	1.4
Ascites																

TABLE 4 (Continued)

	Open								Laparoscopy							
	2016		2017		2018		2019		2016		2017		2018		2019	
	n = 3720		n = 3782		n = 3826		n = 4217		n = 309		n = 386		n = 416		n = 494	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
+	787	21.2	727	19.2	648	16.9	811	19.2	65	21.0	51	13.2	54	13.0	61	12.3
Hypertension																
+	1536	41.3	1567	41.4	1589	41.5	1849	43.8	118	38.2	137	35.5	170	40.9	193	39.1
Congestive heart failure																
+	88	2.4	63	1.7	78	2.0	98	2.3	8	2.6	4	1.0	3	0.7	4	0.8
History of CI																
+	19	0.5	23	0.6	22	0.6	20	0.5	1	0.3	0	0.0	2	0.5	1	0.2
Angina pectoris																
+	63	1.7	42	1.1	47	1.2	64	1.5	2	0.6	3	0.8	4	1.0	6	1.2
Acute renal failure																
+	122	3.3	127	3.4	130	3.4	146	3.5	4	1.3	5	1.3	5	1.2	6	1.2
Dialysis																
+	167	4.5	145	3.8	197	5.1	191	4.5	12	3.9	18	4.7	14	3.4	15	3.0
History of CVD																
+	137	3.7	228	6.0	256	6.7	266	6.3	9	2.9	20	5.2	17	4.1	22	4.5
Long-term steroid use																
+	222	6.0	222	5.9	264	6.9	286	6.8	18	5.8	28	7.3	22	5.3	22	4.5
Risk of hemorrhage																
+	418	11.2	372	9.8	407	10.6	485	11.5	20	6.5	28	7.3	27	6.5	19	3.8
Blood transfusion																
+	117	3.1	108	2.9	126	3.3	116	2.8	4	1.3	3	0.8	7	1.7	5	1.0
Sepsis																
+	478	12.8	495	13.1	921	24.1	1046	24.8	24	7.8	24	6.2	51	12.3	63	12.8
Malignancy																
+	775	20.8	840	22.2	837	21.9	940	22.3	32	10.4	50	13.0	53	12.7	72	14.6

Abbreviations: ADL, activities of daily living; CI, cardiac infarction; COPD, chronic obstructive pulmonary disease; CVD, cerebrovascular disease.

TABLE 5 Surgical findings in patients with colorectal perforation

	Open								Laparoscopy							
	2016		2017		2018		2019		2016		2017		2018		2019	
	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR
Anesthesia time, min	205	167–251	207	168–252	209	170–254	207	168–254	205	160–255	203	157–252	201	157–248	200	152-256
Operating time, min	146	113–185	147	115–186	148	115–188	146	114–188	142	107–185	140	105–181	136	103–185	136	100-190
Estimated blood loss, mL	100	20–335	100	20–312	100	20–320	100	20–300	10	0–58	10	0–50	10	0–50	5	0-80
Transfusion, mL	2100	1400–3000	2100	1411–3050	2100	1443–3068	2006	1390–2900	1800	1220–2550	1700	1100–2300	1750	1158–2400	1545	1051-2290
Length of stay, d	28	17–48	28	17–48	29	17–48	29	17–50	23	14–36	22	14–36	20	14–34	22	14-37
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Drainage alone	1107	29.8	1007	26.6	987	25.8	1088	25.8	112	36.2	139	36.0	156	37.5	160	32.4
Drainage with other surgery	2613	70.2	2775	73.4	2839	74.2	3129	74.2	197	63.8	247	64.0	260	62.5	334	67.6

Abbreviation: IQR, interquartile range.

with malignancy than in those without malignancy in the laparoscopic surgery group.

3.2.5 | Time trend in the use of laparoscopy

The proportion of patients with acute diffuse peritonitis due to colorectal perforation who were treated laparoscopically increased slightly from 7.7% in 2016 to 10.5% in 2019 (Figure 1). There was also an increase in the proportion of institutions that used laparoscopy to treat acute diffuse peritonitis from 18.0% in 2016 to 25.4% in 2019 (Figure 1). The relationship between number of cases per year and rate of laparoscopic surgery for acute diffuse peritonitis due to colorectal perforation in each hospital is shown in Figure S2.

4 | DISCUSSION

In this study we investigated the real-world performance of laparoscopy in patients who underwent surgery for acute diffuse peritonitis due to gastroduodenal or colorectal perforation. Patients whose overall health was poor and those with abnormal laboratory findings tended to undergo open surgery regardless of whether the perforation was gastroduodenal or colorectal. For gastroduodenal perforation, anesthesia and operating times were longer in the laparoscopic surgery group than in the open surgery group and did not change over time. There was a decrease in both anesthesia and operating times year by year in patients who underwent laparoscopic surgery for colorectal perforation. Complications were less common in the laparoscopic surgery group than in the open surgery group whether the perforation was gastroduodenal or colorectal. Regardless of site of perforation, the proportion of surgeries that were performed laparoscopically and the numbers of institutions where laparoscopic surgery was performed increased over time.

Many studies, including ones that have used data from the NCD, have demonstrated the effectiveness of laparoscopy in the elective treatment of abdominal disease.[1-3] Laparoscopy is occasionally used for both diagnosis and treatment of abdominal disease in the emergency setting.[8,9,11] Diagnostic laparoscopy has been reported to be useful in the emergency setting because it can overcome the difficulty sometimes encountered in identification of the cause of acute abdomen by preoperative assessment using abdominal imaging methods such as ultrasound and computed tomography.[12,21] Patients with acute abdomen who cannot be diagnosed accurately often need exploratory surgery, which is invasive and may worsen their physical condition. An inappropriately positioned or wide skin incision may be harmful for patients. Exploratory laparoscopy can facilitate accurate diagnosis of the causative disease in patients with acute abdomen and result in adequate treatment with minimal invasiveness. Furthermore, conversion from laparoscopic surgery to open surgery is considered a useful option in emergency surgery.[22]

It has also been reported that therapeutic laparoscopy may be useful in the emergency setting.[10,14] However, the studies were

TABLE 6 Postoperative complications in patients with colorectal perforation

	Open								Laparoscopy							
	2016		2017		2018		2019		2016		2017		2018		2019	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
30-day mortality																
Total	391	10.5	422	11.2	409	10.7	472	11.2	15	4.9	16	4.1	13	3.1	20	4.0
Malignancy	88	11.4	117	13.9	81	9.7	114	12.1	3	9.4	4	8.0	4	7.5	5	6.9
Non-malignancy	303	10.3	305	10.4	328	11.0	358	10.9	12	4.3	12	3.6	9	2.5	15	3.6
Overall complications																
Grade I	367	9.9	389	10.3	388	10.1	462	11.0	26	8.4	29	7.5	42	10.1	41	8.3
Grade II	761	20.5	823	21.8	783	20.5	914	21.7	62	20.1	57	14.8	74	17.8	82	16.6
Grade III	483	13.0	553	14.6	604	15.8	675	16.0	40	12.9	49	12.7	49	11.8	79	16.0
Grade IV	200	5.4	224	5.9	207	5.4	246	5.8	10	3.2	11	2.8	10	2.4	11	2.2
Grade V	316	8.5	351	9.3	351	9.2	419	9.9	15	4.9	10	2.6	12	2.9	15	3.0
Indications for repeat surgery																
Bleeding	27	0.7	24	0.6	24	0.6	15	0.4	2	0.6	1	0.3	1	0.2	6	1.2
Drainage	92	2.5	74	2.0	96	2.5	108	2.6	8	2.6	6	1.6	9	2.2	9	1.8
Ileus	16	0.4	8	0.2	10	0.3	14	0.3	3	1.0	0	0.0	1	0.2	2	0.4
Other	199	5.3	230	6.1	210	5.5	267	6.3	11	3.6	19	4.9	18	4.3	22	4.5
Superficial incisional SSI																
+	631	17.0	932	24.6	901	23.5	924	21.9	29	9.4	34	8.8	39	9.4	50	10.1
Deep incisional SSI																
+	342	9.2	454	12.0	429	11.2	428	10.1	13	4.2	18	4.7	15	3.6	24	4.9
Organ/Space SSI																
+	355	9.5	411	10.9	436	11.4	483	11.5	20	6.5	42	10.9	31	7.5	39	7.9
Wound disruption																
+	249	6.7	312	8.2	311	8.1	318	7.5	5	1.6	11	2.8	7	1.7	13	2.6
Pneumonia																
+	292	7.8	316	8.4	325	8.5	336	8.0	19	6.1	10	2.6	16	3.8	19	3.8
Unscheduled intratracheal intubation																
+	133	3.6	182	4.8	198	5.2	187	4.4	3	1.0	7	1.8	7	1.7	9	1.8
Pulmonary embolism																
+	16	0.4	20	0.5	20	0.5	14	0.3	1	0.3	0	0.0	3	0.7	1	0.2

(Continues)

TABLE 6 (Continued)

	Open								Laparoscopy							
	2016		2017		2018		2019		2016		2017		2018		2019	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Mechanical ventilation																
+	588	15.8	798	21.1	760	19.9	802	19.0	20	6.5	29	7.5	21	5.0	31	6.3
Renal dysfunction																
+	150	4.0	216	5.7	228	6.0	246	5.8	9	2.9	14	3.6	14	3.4	14	2.8
Acute renal failure																
+	248	6.7	320	8.5	307	8.0	325	7.7	11	3.6	10	2.6	10	2.4	12	2.4
Urinary infection																
+	84	2.3	92	2.4	124	3.2	116	2.8	4	1.3	6	1.6	2	0.5	7	1.4
CNS dysfunction																
+	42	1.1	46	1.2	52	1.4	60	1.4	1	0.3	4	1.0	3	0.7	2	0.4
Cardiac arrest																
+	61	1.6	96	2.5	95	2.5	122	2.9	1	0.3	1	0.3	0	0.0	4	0.8
Myocardial infarction																
+	12	0.3	7	0.2	11	0.3	10	0.2	0	0.0	0	0.0	1	0.2	1	0.2
Blood transfusion																
+	554	14.9	654	17.3	695	18.2	703	16.7	21	6.8	32	8.3	24	5.8	30	6.1
Deep vein thrombosis																
+	33	0.9	54	1.4	56	1.5	72	1.7	2	0.6	3	0.8	5	1.2	2	0.4
Sepsis																
+	503	13.5	727	19.2	996	26.0	1019	24.2	17	5.5	30	7.8	42	10.1	45	9.1

Abbreviations: CNS, central nerve system; SSI, surgical site infection.

observational and the possibility of patient selection bias stemming from the severity of disease cannot be excluded. Most of the studies that have investigated the usefulness of therapeutic laparoscopy have acknowledged the need for both a stable patient and an experienced laparoscopic surgeon as limitations of laparoscopic surgery.

In the present study, we used acute diffuse peritonitis due to gastrointestinal perforation as an example of a disease that typically needs emergency surgery and found that the mortality and complication rates were lower in patients who underwent laparoscopic surgery than in those who underwent open surgery. However, it was not our intention to demonstrate the superiority of laparoscopic surgery for acute diffuse peritonitis due to gastrointestinal perforation; we merely wanted to show the current status of laparoscopic surgery and open surgery for acute diffuse peritonitis. Laparoscopic surgery cannot be performed in patients who are in an extremely poor condition, and there is nothing unusual about the longer length of hospital stay and the higher complication rate in our open surgery group. Acute diffuse peritonitis is common but not a condition that would cause many patients to present at each institution. Therefore, we demonstrated the real-world performance of laparoscopic surgery in this disease using data from a nationwide database.

We found that laparoscopic surgery was more common in patients with acute diffuse peritonitis as a result of gastroduodenal perforation than in those in whom the cause was colorectal perforation. There was an increase in both the proportion of institutions where laparoscopic surgery was performed and the proportion of laparoscopic surgeries performed at each institution over time. The proportion of concurrent surgeries performed for abdominal drainage did not change over time in patients with gastroduodenal perforation but increased in those with colorectal perforation. These findings indicate that emergency laparoscopic surgery for acute diffuse peritonitis is gradually becoming more common even though the proportion remains low, particularly in colorectal surgery.

We exploratorily compared the laparoscopic surgery and open surgery regarding mortality and morbidities and the results showed the superiority of laparoscopic surgery after adjusting for potential confounding factors available in the database. However, we did not present the analysis because we believe that the selection bias between laparoscopic surgery and open surgery could not be reasonably resolved and the results may mislead surgeons regarding the choice of surgical approach in surgery for acute diffuse peritonitis.

The strength of this study is that it used a nationwide surgical database in Japan. The NCD database covers almost all surgeries performed in the country. Moreover, it included data for the two main types of causes of acute diffuse peritonitis. However, the study also has some limitations, which stem mainly from its retrospective design. For example, the accuracy of the data collected relied on the accuracy of data input at each institution and whether data were entered into the NCD on an annual basis. Although there might be an effect of recall bias and transcription errors during the input procedure on the quality of data in the NCD, the quality of these data has been reported to be high.[23] Patient selection bias was inevitable, and we did not investigate for this according to whether surgery was laparoscopic or open. However, the trend observed over time suggests the increased use of laparoscopic surgery for acute diffuse peritonitis over time and its potential usefulness in the emergency setting.

In conclusion, laparoscopic surgery is becoming common for acute diffuse peritonitis due to gastrointestinal perforation. Although the number of candidates for emergency laparoscopic surgery might be limited, laparoscopic surgery may be a useful option for acute diffuse peritonitis.

DISCLOSURE

Funding: This study was supported by a grant from the Japanese Society for Abdominal Emergency Medicine.

Conflict of Interest: Hideki Endo has received research expenses or scholarship donations from the National Clinical Database. Hiraku Kumamaru has received speaker fees from Pfizer Japan Inc. and Johnson & Johnson KK, and consultation fees from Mitsubishi Tanabe Pharma Corp. Hiraku Kumamaru is affiliated with the Department of Healthcare Quality Assessment at the University of Tokyo, which is a social collaboration department supported by the National Clinical Database, Johnson & Johnson KK, and Nipro Corp. Yuko Kitagawa has received lecture fees from Chugai Pharmaceutical Co., Ltd., Taiho Pharmaceutical Co., Ltd., Asahi Kasei Pharma Corp., Otsuka Pharmaceutical Factory, Inc., Ono Pharmaceutical Co., Ltd., Shionogi & Co., Ltd., Nippon Covidien Inc., AstraZeneca KK, Ethicon Inc., Bristol-Myers Squibb KK, and Olympus Corp. Yuko Kitagawa has received research expenses or scholarship donations from Chugai Pharmaceutical Co., Ltd., Taiho Pharmaceutical Co., Ltd., Yakult Honsha Co., Ltd., Asahi Kasei Pharma Corp., Otsuka Pharmaceutical Co., Ltd., Ono Pharmaceutical Co., Ltd., Tsumura & Co., Kaken Pharmaceutical Co., Ltd., Dainippon Sumitomo Pharma Co., Ltd., EA Pharma Co., Ltd., Eisai Co., Ltd., Otsuka Pharmaceutical Factory, Inc., Medicon Inc Kyowa Hakkou Kirin Co., Ltd., Takeda Pharmaceutical Co., Ltd., Toyama Chemical Co., Ltd., Astellas Pharma Inc., Teijin Pharma Ltd.., Nihon Pharmaceutical Co., Ltd., and Nippon Covidien Inc. Yuko Kitagawa is the endowed chair of Chugai Pharmaceutical Co., Ltd. and Taiho Pharmaceutical Co., Ltd. Hiroaki Miyata is the endowed chair of the National Clinical Database, Johnson & Johnson KK, and Nipro Corp. For the remaining authors, none were declared.

The funding for this study was provided by the Japanese Society for Abdominal Emergency Medicine. The funding source had no role in the design, practice, or analysis of this study.

Approval of the Research Protocol by an Institutional Reviewer Board: The study was approved by the Ethics Committee of Kyoto University (approval number R2777).

Informed Consent (if applicable): N/A.

Registry and the Registration No. of the Study/Trial: Not registered.

Animal Studies (if applicable): N/A.

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SUPPORTING INFORMATION

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How to cite this article: Hoshino N, Endo H, Hida K, Kumamaru H, Hasegawa H, Ishigame T, et al. Laparoscopic Surgery for Acute Diffuse Peritonitis Due to Gastrointestinal Perforation: A Nationwide Epidemiologic Study Using the National Clinical Database. Ann Gastroenterol Surg. 2022;6:430–444. https://doi.org/10.1002/ags3.12533