JIMA Vol. 75, No. 3 (Aug 2023) pp. 81-94.

Original

A novel difficulty scoring system for laparoscopic colorectal cancer surgery for appropriate case selection according to master

Yu ARIYOSHI [1)], Koki OTSUKA [2)], Mizunori YAEGASHI [1)], Kiyoharu TAKASHIMIZU [1)], Tomoki HATANAKA [1)], Yuya NAKAMURA [1)], Tomoko SASAKI [1)], Fumiaki TAKAHASHI [3)] and Akira SASAKI [1)]

[1)] Department of Surgery, School of Medicine, Iwate Medical University, Yahaba, Japan

[2)] Department of Advanced Robotic and Endoscopic Surgery, Fujita Health University, Toyoake, Japan

[3)] Center for Liberal Arts and Sciences, Iwate Medical University, Yahaba, Japan

(Received on January 10, 2023 & Accepted on January 20, 2023)

Abstract

Mastering laparoscopic colorectal cancer surgery involves a learning curve. Inexperienced surgeons require appropriate case selection. Nonetheless, there are few indicators for predicting the difficulty of laparoscopic colorectal cancer surgery. We established a difficulty scoring system to facilitate appropriate case selection during the learning curve for laparoscopic colorectal cancer surgery until mastery is achieved.

We reviewed 1,390 laparoscopic colorectal cancer surgery cases performed at our hospital. Surgical duration was used as an index of surgical difficulty. Factors related to surgical difficulty were identified using a multivariate analysis and were scored using a linear regression analysis.

Overall, 889 patients were included in the analysis. Sex, body mass index > 25 kg/m^2, and tumor location were factors that best defined surgical difficulty. The difficulty was determined by the sum of prolonged surgical duration predicted by these three factors. Surgical duration and hospital stay were longer, blood loss was greater, and complications were more common in the high difficulty group than in the low and medium difficulty groups. The developed scoring system showed high reliability in ten-fold cross-validation.

The scoring model we developed can predict surgical difficulty for typical laparoscopic colorectal cancer surgery and may be useful in selecting appropriate surgical cases for inexperienced surgeons.

Key words : laparoscopic colorectal surgery, colorectal cancer, learning curve, cross validation, scoring system

I. Introduction

Colorectal cancer is the third most common cancer diagnosed worldwide, with approximately 1,800,000 new cases and approximately 881,000 deaths in 2018[1)]. Long-term results of laparoscopic colorectal cancer surgery (LCCS) have not been reported to be inferior to those obtained in open surgery[2-6)]. The American Society of Colon and Rectal Surgeons describes

Corresponding author: Yu Ariyoshi
ariyoshi@iwate-med.ac.jp

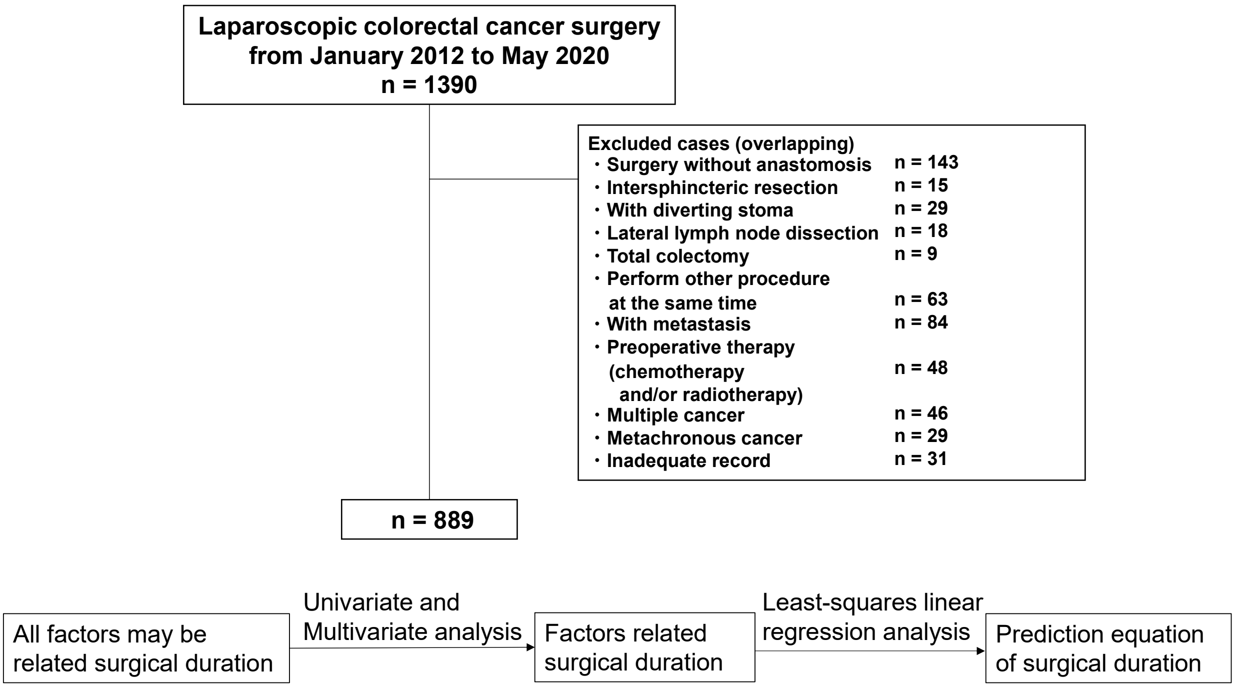

Fig. 1. The study flow chart depicting the exclusion criteria and study methods for this study.

LCCS as a minimally invasive approach[7, 8], and laparoscopic surgery has become a widely used method for colorectal cancer treatment in Japan[9]. However, this procedure should be performed by experienced surgeons to ensure that the short-term and long-term results are equivalent to those of open surgery[7–9]. In particular, transverse and descending colon cancers are excluded from open versus laparoscopic trials due to their anatomical complexity, and laparoscopic surgery should be carefully considered in particular circumstances, such as with T4 colon cancer, larger-sized tumors, locally advanced cancer, and comorbidities with obesity[2-4, 10-14]. Although it is very difficult to evaluate the skills of each surgeon and those available at each institution, differences in the outcomes of LCCS between institutions have been reported[12, 15].

Some experience is required to learn LCCS[3, 16]. Nonetheless, there has been no report on an objective index of the types of cases that are suitable for inexperienced surgeons while learning to master the technique. Therefore, the present study aimed to construct a scoring system to predict the surgical difficulty of LCCS and to facilitate appropriate case selection according to the surgeon's proficiency.

II. Materials and Methods

1. Patients

We retrospectively analyzed cases of LCCS performed at our hospital. The study protocol was approved by the Research Ethics Committee of Iwate Medical University School of Medicine (MH2019-121). Informed consent for laparoscopic surgery was obtained from all patients. A total of 1,390 cases of LCCS performed on a standby basis at our hospital between January 2012 and May 2020 were included in this study. The exclusion criteria for this study were surgery without anastomosis (Hartmann's surgery and abdominoperineal resection), intersphincteric resection, surgery with a diverting stoma, lateral lymph node dissection, total colectomy, simultaneous performance of other procedures, with metastasis, preoperative therapy (chemotherapy and/or radiotherapy), multiple cancers, metachronous cancers, and incomplete medical records (Fig. 1). Tumor location was confirmed by barium enema or computed tomography colonography in all cases.

2. Study design

During the study period (2012–2020), there were two qualified surgeons at our institution, based on using the endoscopic surgical skill qualification system in Japan[17] in the field of colorectal surgery, and they participated as surgeons or assistants in all cases included in this study. In this study, the surgical difficulty index was defined as the surgical duration. Factors affecting surgical duration were analyzed, including age, sex, body mass index (BMI), American Society of Anesthesiologists Physical Status (ASA-PS), tumor location, previous open surgery, T category, N category, tumor stage, and surgeries performed by an endoscopic surgical skill qualification system-qualified surgeon. Ordinal and nominal variables were analyzed as is. Cutoff values were defined for the continuous variables of age and BMI. The cutoff value for age was 65 years old, which is defined as elderly by the World Health Organization, and the cutoff value for BMI was 25, which is defined as obese by the Japan Society for the Study of Obesity.

First, factors related to surgical duration were analyzed univariately, and a multivariate analysis was performed on the extracted factors. Second, predictive equations for surgical duration were developed using a least-squares linear regression model for the factors extracted in the multivariate analysis. Third, the prolongation time was calculated from this prediction equation, and surgical difficulty was accordingly divided into the following three groups according to the total prolongation time: low, medium, and high difficulty. Fourth, surgical duration, blood loss, conversion to open surgery, complications, and length of postoperative hospital stay were evaluated among the three difficulty groups. Postoperative complications were evaluated according to the Clavien-Dindo classification[18]. Finally, 10-fold cross-validation was performed to assess this scoring system.

3. Surgical procedure

General anesthesia and pneumoperitoneum were administered to all patients. Abdominal air pressure was set at 8-10 mmHg. In all cases, the lithotomy position was used during surgery. The surgeon, assistant surgeon, and scopist performed the operation using five ports. A medial approach with central lymph node dissection was used first in any surgical design. Any surgeon performed the surgery, which was standardized in our facility[19]. Functional end-to-end anastomosis or a double-stapling technique was used for intestinal anastomosis, depending on tumor location. All functional end-to-end anastomoses were performed extracorporeally.

We performed D3 dissection for colorectal cancer based on the Japanese guidelines[9]. Both proximal and distal margins were 10 cm beyond the tumor, and complete dissection was performed for all regional lymph nodes. In

Table 1. Patients and tumor characteristics

Variables
Age (year), median (range)
Sex (male), n (%)
BMI (kg/m²), median (range)
ASA-PS (1, 2, 3, 4), n (%)
Previous open surgery, n (%)
Tumor location (C, A, T, D, S, RS, Ra, Rb), n (%)
T category (Tis, T1, T2, T3, T4a, T4b), n(%)
N category (N0, N1a, N1b, N2a, N2b, N3), n (%)
Stage (0, I, II a, II b, II c, III a, III b, III c), n (%)
Percentage of surgeries performed by endoscopic surgical skill qualified surgeon (C, A, T, D, S, RS, Ra, Rb, all procedure), n (%)

BMI, Body mass index; ASA-PS, American Society of Anesthesiologists Physical Status; C, cecum; A, ascending colon; T, transverse colon; D, descending colon; S, sigmoid colon; RS, rectosigmoid colon; Ra, rectum above the peritoneal reflection; Rb, rectum below the peritoneal reflection.

ileocecal resection, the ileocecal vessels were divided, and the lymph nodes were dissected. In addition to this, the right colonic artery and the right branch of the middle colonic artery were divided, and the lymph nodes were dissected in right hemicolectomy. For partial resection of the transverse colon, the lymph nodes at the root of the middle colonic artery were dissected, and the root or only the right or left branch of the middle colonic artery was divided, depending on tumor location. In left hemicolectomy, the left colonic artery and the left branch of the middle colonic artery were divided. The lymph nodes at the root of the inferior mesenteric artery were also dissected; however, the inferior mesenteric artery itself was preserved. In sigmoidectomy and rectal resection, the inferior mesenteric artery was divided at its root, or the left colonic artery was preserved and divided on the peripheral side after dissecting the lymph nodes at the root. In Japan, this type of surgery is commonly performed as D3 lymph node dissection[20-22].

4. Statistical analysis

Categorical variables are expressed as total numbers and percentages, whereas continuous data are presented as median values. The chi-square test was employed for categorical data, whereas the Kruskal–Wallis test or Steel–Dwass test was used for continuous data. Multivariate analysis was performed on factors extracted by univariate analysis. Statistical significance was considered as p-values < 0.05. A least-squares linear regression model was used to determine factors affecting the surgical duration for the assessment of surgical difficulty. All statistical analyses were performed using JMP software version 16.0.0 (SAS Institute, Inc., Cary, NC, USA).

III. Results

1. Patient background and surgical outcomes

Out of 1,390 patients, 501 were excluded, leaving 889 patients for analysis. The

n = 889
68 (24–94)
456 (51.3)
23.1 (12.5–56.3)
164 (18.4), 617 (69.4), 106 (11.9), 2 (0.2)
141 (15.9)
98 (11.0), 125 (14.1), 92 (10.3), 49 (5.5), 226 (25.4),111 (12.5), 103 (11.6), 85 (9.6)
9 (1.0), 181 (20.4), 155 (17.4), 490 (55.1), 48 (5.4), 6 (0.7)
555 (62.4), 125 (14.1), 108 (12.1), 68 (7.6), 33 (3.7), 0 (0.0)
8 (0.9), 280 (31.5), 254 (28.6), 10 (1.1), 3 (0.3), 51 (5.7), 241 (27.1), 42 (4.7)
45 (45.9), 71 (56.8), 81 (88.0), 38 (77.6), 81 (35.8), 83 (74.8), 96 (93.2), 82 (96.5), 577 (64.9)

background and surgical results of the analyzed cases are shown in Tables 1 and 2, respectively. The surgical technique was selected according to the Japanese classification of colorectal cancer, based on tumor location[23]. There were 171 ileocecal resections, 91 right hemicolectomies, 56 partial resections of the transverse colon, 49 left hemicolectomies, 223 sigmoidectomies, 112 high anterior resections, and 187 low anterior resections. The percentage of surgeries performed by surgeons qualified by the endoscopic surgical skill qualification system was relatively high for the transverse colon, descending colon, and lower rectum procedures. The median surgical duration for all operations was 187 minutes (interquartile range [IQR] 160–218 minutes), and the median blood loss was 10 mL (IQR 5–18 mL). In seven patients (0.8%), the procedure was converted to open surgery. The median length of postoperative hospital stay was 8 days (IQR 7–10 days). Complications with Clavien-Dindo classification ≧ 3 occurred in 30 patients (3.4%). No operative mortality was observed.

2. Factors determining surgical difficulty and scoring model for LCCS

Univariate analysis showed that male sex, BMI ≧ 25 kg/m^2, and tumor location were associated with prolonged surgical duration. In the multivariate analysis, these associations remained significant (Table 3). Using these three factors, a prediction equation for surgical duration was obtained by least-squares linear regression analysis (Fig. 2). The degree of prolongation associated with each of these factors obtained using this prediction equation was used as a score (Table 4). For example, 11.6 + 12.0 + 24.7 = 48.3 for males, BMI ≧ 25 kg/m^2, and tumor location in the transverse colon and 0 + 0 + 10.3 = 10.3 for females, BMI <25 kg/m^2, and tumor location in the sigmoid colon. The total score was used to determine the difficulty of the case. Surgical difficulty was classified into three levels: low difficulty, score ≦ 20; medium

Table 2. Operative outcomes of the laparoscopic colorectal cancer surgery

Operative procedure	Ileocecal resection	Right hemicolectomy	Partial resection of the transverse colon
Number of patients	171	91	56
Surgical duration (minutes), median (IQR)	170 (145–199)	192 (165–222)	191(154–214)
Blood loss (mL), median (IQR)	12 (7–21)	14 (7–24)	10 (7–30)
Conversion to open surgery, n (%)	2 (1.2)	3 (3.3)	0 (0.0)
Postoperative hospital stay (day), median (IQR)	8 (7–11)	8 (7–10)	9 (7–10)
Morbidity Clavien–Dindo			
grade ≧ 3, n (%)	4 (2.3)	2 (2.2)	1 (1.8)
Mortality, n (%)	0 (0.0)	0 (0.0)	0 (0.0)

IQR, interquartile range

Table 3. Correlations between surgical duration and clinical factors

Independent variables	Univariate analysis p value*	Multivariate analysis p value**
Age ≧ 65 years	0.0586	
Sex	< 0.0001	< 0.0001
BMI ≧ 25 kg/m^2	< 0.0001	< 0.0001
ASA-PS	0.1686	
Tumor location	< 0.0001	< 0.0001
Previous open surgery	0.9065	
T category	0.2086	
N category	0.2499	
Stage	0.4907	
Surgeries performed by endoscopic surgical skill qualified surgeon	0.1708	

* Wilcoxon signed rank test
** Multiple regression analysis, least squares method
BMI, body mass index; ASA-PS, American Society of Anesthesiologists Physical Status.

difficulty, score 20–40; and high difficulty >40.

3. Evaluation by the scoring model

Median (IQR) surgical duration (minutes) was significantly different for each difficulty level: low vs. medium (170 [147–197] vs. 186 [160–213], respectively, p < 0.0001), medium vs. high (186 [160–213] vs. 204 [180–236], respectively, p < 0.0001), and low vs. high (170 [147–197] vs. 204 [180–236], respectively, p < 0.0001). Blood loss and postoperative hospital stay also significantly differed by difficulty level (Table 5). The rate of conversion to open surgery was not related to the degree of difficulty. The incidence of complications with Clavien–Dindo classification ≧ 3 significantly increased with difficulty.

4. Reliability of the scoring model

In validation set A, the concordance rate

Left hemicolectomy	Sigmoidectomy	High anterior resection	Low anterior resection	All procedure
49	223	112	187	889
205 (179–241)	179 (152–211)	187 (161–222)	200 (180–226)	187 (160–218)
19 (11–34)	7 (4–14)	8 (5–15)	8 (5–17)	10 (5–18)
0 (0.0)	2 (0.9)	0 (0.0)	0 (0.0)	7 (0.8)
8 (7–10)	7 (7–9)	8 (7–10)	10 (8–12)	8 (7–10)
1 (2.0)	5 (2.2)	1 (0.9)	16 (8.6)	30 (3.4)
0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

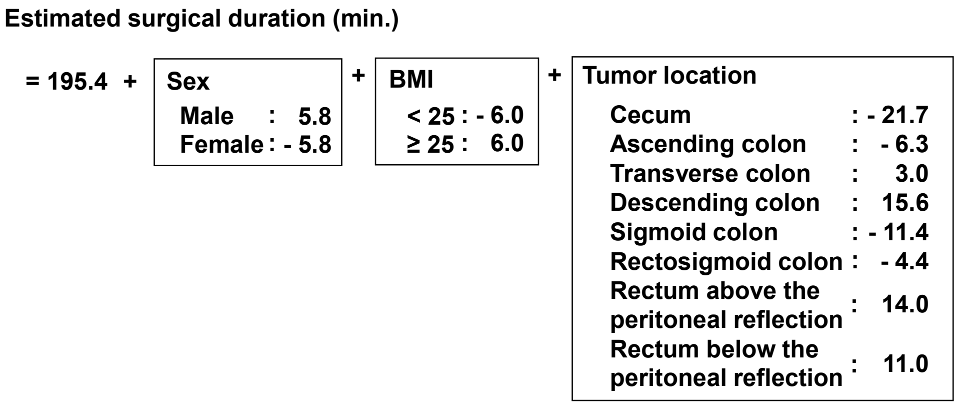

Fig. 2. The expected surgical duration was calculated by least-squares linear regression analysis. The expected surgical duration (minutes) was calculated by summing 195.4 + the value defined by Sex + the value defined by BMI + the value defined by tumor location.

of the scoring model was 92.1% (Fig. 3). Similarly, the average concordance rate calculated using 10 validation sets for the created scoring model was 92.8%.

Ⅳ. Discussion

To date, there have been no indicators guiding case selection for inexperienced surgeons to learn LCCS. The scoring system developed in this study allowed for the stratification of patients into three groups based on three factors: sex, BMI, and tumor location. Ten-fold cross-validation analysis verified the reliability of the scoring system. Surgical duration, blood loss, and complications increased with increasing surgical difficulty.

Although some studies have used the rate of conversion to open surgery or complications to evaluate surgical difficulty[24–26], the rate of conversion to open surgery was as low as 0.8%, the amount of blood loss was as low as 10 mL, and there were fewer complications in the present study, as compared to other reports[16, 27]. Therefore, the surgical duration was used as the index of surgical difficulty in this study. The reason for the low complication rate seemed to be the presence of endoscopic surgical skill qualification-certified

Table 4. Novel model for difficulty score of laparoscopic colorectal cancer surgery

Sex	Male	11.6
	Female	0.0
BMI	< 25	0.0
	≧ 25	12.0
Tumor location	Cecum	0.0
	Ascending colon	15.4
	Transverse colon	24.7
	Descending colon	37.3
	Sigmoid colon	10.3
	Rectosigmoid colon	17.3
	Rectum above the peritoneal reflection	35.9
	Rectum below the peritoneal reflection	32.7

Total score < 20 : Low difficulty
20 ≦ Total score < 40 : Medium difficulty
40 ≦ Total score : High difficulty

BMI, body mass index

Table 5. Operative outcomes for the three levels of surgical difficulty identified using our scoring model

	Low difficulty n = 268	Medium difficulty n = 362	High difficulty n = 259	p value*		
				L vs M	M vs H	L vs H
Surgical duration (minutes), median (IQR)	170 (147–197)	186 (160–213)	204 (180–236)	< 0.0001	< 0.0001	< 0.0001
Blood loss (mL), median (IQR)	8 (5–16)	10 (5–18)	13 (6–22)	0.3249	0.0036	< 0.0001
Postoperative hospital stay (days), median (IQR)	8 (7–10)	8 (7–10)	10 (8–11)	0.3732	< 0.0001	< 0.0001
Conversion to open surgery, n (%)	2 (0.7)	5 (1.4)	0 (0.0)		0.1576	
Morbidity (Clavien–Dindo grade ≧ 3), n (%)	5 (1.9)	10 (2.8)	15 (5.8)		0.0313	

* Steel–Dwass test for continuous data, and the chi square test for categorical data
IQR, interquartile range; L, low difficulty; M, medium difficulty; H, high difficulty

surgeons at our institution[17, 28]. and the use of a standardized surgical technique[19, 29].

Sex, BMI, tumor location, obesity, and locally advanced cancer have all been reported as factors that define surgical difficulty[24–26, 30, 31]. In this study, three factors influenced surgical difficulty: sex, BMI, and tumor location. Differences in difficulty based on sex seem to be due to the decrease in operability and visibility caused by the relatively larger visceral fat area in males[32], and the influence of pelvic volume on the difficulty of rectal cancer surgery[33, 34]. During surgery in obese patients with a high BMI score, manipulation of a thickened mesentery and maneuvering of instruments in a restricted area make dissection difficult[35]. Surgical difficulty is also affected by the tumor location: For instance,

A

Estimated surgical duration (min.) = 195.5 + Sex (Male : 5.8; Female : - 5.8) + BMI (< 25 : - 6.0; ≥ 25 : 6.0)

+ Tumor location

Tumor location	
Cecum	: - 21.7
Ascending colon	: - 6.3
Transverse colon	: 3.0
Descending colon	: 15.6
Sigmoid colon	: - 11.4
Rectosigmoid colon	: - 4.4
Rectum above the peritoneal reflection	: 14.0
Rectum below the peritoneal reflection	: 11.0

B

Sex	Male	11.6
	Female	0
BMI ≥ 25 kg/㎡	< 25	0
	≥ 25	12.0
Tumor location	Cecum	0
	Ascending colon	15.4
	Transverse colon	24.7
	Descending colon	37.3
	Sigmoid colon	10.3
	Rectosigmoid colon	17.3
	Rectum above the peritoneal reflection	35.9
	Rectum below the peritoneal reflection	32.7

total score ＜ 20 : low difficulty
20 ≤ total score ＜ 40 : medium difficulty
40 ≤ total score : high difficulty

C

		Difficulty grade from total data		
		high	medium	low
Difficulty grade from training set A	high	28	2	0
	medium	4	36	0
	low	0	1	18

D

Concordance rate
= (high × high + medium × medium + low × low) / total number
= 0.921

Fig. 3. The concordance rate of the difficulty grade was calculated using validation set A.
(A) The expected surgical duration in the training set was calculated using least-squares linear regression analysis.
(B) Created scoring system of the training set from expected surgical duration.
(C) Difficulty classification table for testing set was created by the difficulty grade from total data and the difficulty grade from training set.
(D) The concordance rate was calculated as the value that matched in both scoring systems.

the anatomical complexity of blood vessels associated with transverse colon cancer and the difficulty of surgical techniques, such as mobilization of the splenic flexion in descending colon cancer, are likely to increase the difficulty[10-12]. For rectal cancer, the distance from the anal verge and the size of the tumor affect the difficulty of the procedure[31]. However, in this scoring system, the predicted surgical duration in the rectal region was longer in the cases involving the rectum above the peritoneal reflection than in the cases involving the rectum below the peritoneal reflection. This may be because tumors at the rectum above the peritoneal reflection required mesorectal dissection as Tumor-Specific Mesorectal Excision.

Differences in the short-term[36-38] and long-term[39-41] outcomes of LCCS have been reported to be influenced by the surgeon's experience and hospital heterogeneity. Similarly, in the JCOG0404 study conducted in Japan, the 5-year survival rate for colon cancer was good in both the open and laparoscopic surgery groups; however, the prognosis for laparoscopic surgery tended to be worse for particular tumor locations, advanced cancer, and obese patients[12]. Thus, experienced surgeons often need to perform difficult LCCS procedures.

In our institution, the surgical procedure is selected according to the Japanese classification and guidelines for colorectal cancer treatment based on tumor location. For decades, D3 dissection, not complete mesocolic excision (CME), has been performed for colorectal cancer in Japan. The superiority of CME with central vascular ligation or D3 dissection for colorectal cancer has not yet been established. Theoretically, the Japanese D3 and CME techniques are equivalent; which of these is more suitable for colorectal cancer surgery remains unclear, and both result in optimal outcomes[12, 20-22]. In this study, we evaluated the standard Japanese procedure based on D3 dissection.

With respect to the learning curve for novice surgeons with no experience in LCCS, 30–50 cases should be operated on in order to master the procedure[42-44]. It is important that surgeons gain experience in cases that are appropriate to their proficiency until mastery is achieved. Scoring systems for laparoscopic hepatectomy[45, 46] and laparoscopic cholecystectomy[47-49] can predict the difficulty of these procedures. Furthermore, scoring systems for laparoscopic rectal cancer surgery[50] and laparoscopic total mesorectal excision[51] in the colorectal region have been reported. In addition, a scoring system that quantifies the difficulty of each aspect of laparoscopic colorectal surgery (i.e., exposure, dissection, isolation of the vascular pedicle, mobilization of the specimen, and anastomosis), including that for benign diseases[52], and a difficulty prediction model that examines the rate of conversion to open surgery[53, 54] have been reported. However, no previous study has examined a scoring system for LCCS that considers a number of risk factors affecting surgical difficulty. This scoring system may help in appropriate case selection while relatively inexperienced surgeons learn the LCCS techniques, and is expected to reduce unexpected complications and conversion to open surgery.

Limitations

This study was a single-center retrospective analysis. Thus, it is desirable to validate the scoring system developed in this study using surgical data from other institutions. In addition, we devised a scoring system tailored to case selection for the introduction of LCCS, and the exclusion criteria included highly difficult surgeries. Therefore, we did not consider factors that would make a low anterior resection even more difficult, such as surgery after chemoradiotherapy. It will be necessary to verify whether case selection using this scoring system can shorten the learning curve and the time required to master surgical techniques and reduce the rate of complications and conversion to open surgery.

In conclusion, we established a scoring system for appropriate case selection for relatively inexperienced surgeons learning the skills to master the technique of LCCS, and it would be useful as an indicator for expanding the application to more difficult cases of LCCS. The consistency of the results was confirmed by 10-fold cross-validation. This scoring system is likely to improve patient safety through appropriate case selection according to the surgeon's proficiency.

Acknowledgements

The authors thank all members of Department of Surgery, Iwate Medical University, School of Medicine for their excellent assistance, as well as Editage (www.editage.jp) for the English language review.

Conflicts of Interest: The authors have no conflict of interest to declare.

References

1) **Arnold M, Abnet CC, Neale RE, et al.**: Global burden of 5 major types of gastrointestinal cancer. Gastroenterology **159**, 335-349, 2020.
2) **Buunen M, Veldkamp R, Hop WC, et al.**: Survival after laparoscopic surgery versus open surgery for colon cancer: long-term outcome of a randomised clinical trial. Lancet Oncol **10**, 44-52, 2009.
3) **Nelson H, Sargent DJ, Wieand HS, et al.**: A comparison of laparoscopically assisted and open colectomy for colon cancer. N Engl J Med **350**, 2050-2059, 2004.
4) **Lacy AM, García-Valdecasas JC, Delgado S, et al.**: Laparoscopy-assisted colectomy versus open colectomy for treatment of non-metastatic colon cancer: a randomised trial. Lancet **359**, 2224-2229, 2002.
5) **Jayne DG, Guillou PJ, Thorpe H, et al.**: Randomized trial of laparoscopic-assisted resection of colorectal carcinoma: 3-year results of the UK MRC CLASICC Trial Group. J Clin Oncol **25**, 3061-3068, 2007.
6) **Deijen CL, Vasmel JE, de Lange-de Klerk ESM, et al.**: Ten-year outcomes of a randomised trial of laparoscopic versus open surgery for colon cancer. Surg Endosc **31**, 2607-2615, 2017.
7) **Vogel JD, Eskicioglu C, Weiser MR, et al.**: The American Society of Colon and Rectal Surgeons clinical practice guidelines for the treatment of colon cancer. Dis Colon Rectum **60**, 999-1017, 2017.
8) **You YN, Hardiman KM, Bafford A, et al.**: The American Society of Colon and Rectal Surgeons clinical practice guidelines for the management of rectal cancer. Dis Colon Rectum **63**, 1191-1222, 2020.
9) **Hashiguchi Y, Muro K, Saito Y, et al.**: Japanese Society for Cancer of the Colon and Rectum (JSCCR) guidelines 2019 for the treatment of colorectal cancer. Int J Clin Oncol **25**, 1-42, 2020.
10) **Milone M, Degiuli M, Allaix ME, et al.**: Mid-transverse colon cancer and extended versus transverse colectomy: Results of the Italian Society of Surgical Oncology Colorectal Cancer Network (SICO CCN) multicenter collaborative study. Eur J Surg Oncol **46**, 1683-1688, 2020.
11) **Akiyoshi T, Kuroyanagi H, Oya M, et al.**: Factors affecting difficulty of laparoscopic surgery for left-sided colon cancer. Surg Endosc **24**, 2749-2754, 2010.
12) **Kitano S, Inomata M, Mizusawa J, et al.**: Survival outcomes following laparoscopic versus open D3 dissection for stage II or III colon cancer (JCOG0404): a phase 3, randomised controlled trial. Lancet Gastroenterol Hepatol **2**, 261-268, 2017.
13) **Mistrangelo M, Allaix ME, Cassoni P, et al.**: Laparoscopic versus open resection for transverse colon cancer. Surg Endosc **29**, 2196-2202, 2015.

14) **Green BL, Marshall HC, Collinson F, et al.**: Long-term follow-up of the Medical Research Council CLASICC trial of conventional versus laparoscopically assisted resection in colorectal cancer. Br J Surg **100**, 75-82, 2013.
15) **Kuhry E, Bonjer HJ, Haglind E, et al.**: Impact of hospital case volume on short-term outcome after laparoscopic operation for colonic cancer. Surg Endosc **19**, 687-692, 2005.
16) **Guillou PJ, Quirke P, Thorpe H, et al.**: Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. Lancet **365**, 1718-1726, 2005.
17) **Akagi T, Endo H, Inomata M, et al.**: Clinical impact of Endoscopic Surgical Skill Qualification System (ESSQS) by Japan Society for Endoscopic Surgery (JSES) for laparoscopic distal gastrectomy and low anterior resection based on the National Clinical Database (NCD) registry. Ann Gastroenterol Surg **4**, 721-734, 2020.
18) **Dindo D, Demartines N** and **Clavien PA**: Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg **240**, 205–213, 2004.
19) **Otsuka K, Kimura T, Hakozaki M, et al.**: Comparative benefits of laparoscopic surgery for colorectal cancer in octogenarians: a case-matched comparison of short- and long-term outcomes with middle-aged patients. Surg Today **47**, 587-594, 2017.
20) **Kobayashi H** and **West NP** : CME versus D3 dissection for colon cancer. Clin Colon Rectal Surg **33**, 344-348, 2020.
21) **West NP, Kobayashi H, Takahashi K, et al.**: Understanding optimal colonic cancer surgery: comparison of Japanese D3 resection and European complete mesocolic excision with central vascular ligation. J Clin Oncol **30**, 1763-1769, 2012.
22) **Ishiguro M, Higashi T** and **Watanabe T**: Changes in colorectal cancer care in Japan before and after guideline publication: a nationwide survey about D3 lymph node dissection and adjuvant chemotherapy. J Am Coll Surg **218**, 969-977, 2014.
23) Japanese Society for Cancer of the Colon and Rectum : Japanese classification of colorectal, appendiceal, and anal carcinoma: the 3d. English ed. [secondary publication]. J Anus Rectum Colon. **3**, 175-195, 2019.
24) **Thorpe H, Jayne DG, Guillou PJ, et al.**: Patient factors influencing conversion from laparoscopically assisted to open surgery for colorectal cancer. Br J Surg **95**, 199-205, 2008.
25) **Tekkis PP, Senagore AJ, Delaney CP, et al.**: Evaluation of the learning curve in laparoscopic colorectal surgery: comparison of right-sided and left-sided resections. Ann Surg **242**, 83-91, 2005.
26) **He Y, Wang J, Bian H, et al.**: BMI as a predictor for perioperative outcome of laparoscopic colorectal surgery: a pooled analysis of comparative studies. Dis Colon Rectum **60**, 433-445, 2017.
27) **van der Pas MH, Haglind E, Cuesta MA, et al.**: Laparoscopic versus open surgery for rectal cancer (COLOR II): short-term outcomes of a randomised, phase 3 trial. Lancet Oncol. **14**, 210-218, 2013.
28) **Mori T, Kimura T** and **Kitajima M**: Skill accreditation system for laparoscopic gastroenterologic surgeons in Japan. Minim Invasive Ther Allied Technol. **19**, 18-23, 2010.
29) **Otsuka K, Kimura T, Matsuo T, et al.**: Laparoscopic low anterior resection with two planned stapler fires. JSLS **23**, e2018, 2019.
30) **Fung A, Trabulsi N, Morris M, et al.**: Laparoscopic colorectal cancer resections in the obese: a systematic review. Surg Endosc **31**, 2072-2088, 2017.
31) **Ye C, Wang X, Sun Y, et al.**: A nomogram predicting the difficulty of laparoscopic surgery for rectal cancer. Surg Today **51**, 1835-1842, 2021.
32) **Palmer BF** and **Clegg DJ**: The sexual dimorphism of obesity. Mol Cell Endocrinol **402**, 113-119, 2015.
33) **Toyoshima A, Nishizawa T, Sunami E, et al.**: Narrow pelvic inlet plane area and obesity as risk factors for anastomotic leakage after intersphincteric resection. World J Gastrointest Surg **12**, 425-434, 2020.
34) **Rullier E, Laurent C, Garrelon JL, et al.**: Risk factors for anastomotic leakage after resection of rectal cancer. Br J Surg **85**, 355–358, 1998.
35) **Yang T, Wei M, He Y, et al.**: Impact of visceral obesity on outcomes of laparoscopic colorectal surgery: a meta-analysis. ANZ J Surg **85**, 507-513, 2015.
36) **Jestin P, Påhlman L** and **Gunnarsson U**: Risk factors for anastomotic leakage after rectal

cancer surgery: a case-control study. Colorectal Dis **10**, 715-721, 2008.

37) **Cong ZJ, Fu CG, Wang HT, et al.**: Influencing factors of symptomatic anastomotic leakage after anterior resection of the rectum for cancer. World J Surg **33**, 1292-1297, 2009.

38) **Iversen LH, Harling H, Laurberg S, et al.**: Influence of caseload and surgical speciality on outcome following surgery for colorectal cancer: a review of evidence. Part 1: Short-term outcome. Colorectal Dis **9**, 28-37, 2007.

39) **Archampong D, Borowski D, Wille-Jørgensen P, et al.**: Workload and surgeon's specialty for outcome after colorectal cancer surgery. Cochrane Database Syst Rev **3**, CD005391, 2012.

40) **Iversen LH, Harling H** and **Laurberg S**: Influence of caseload and surgical speciality on outcome following surgery for colorectal cancer: a review of evidence. Part 2: Long-term outcome. Colorectal Dis **9**, 38–46, 2007.

41) **Lange MM, Martz JE, Ramdeen B, et al.**: Long-term results of rectal cancer surgery with a systematical operative approach. Ann Surg Oncol **20**, 1806-1815, 2013.

42) **Akiyoshi T, Kuroyanagi H, Ueno M, et al.**: Learning curve for standardized laparoscopic surgery for colorectal cancer under supervision: a single-center experience. Surg Endosc **25**, 1409-1414, 2011.

43) **Li JC, Hon SS, Ng SS, et al.**: The learning curve for laparoscopic colectomy: experience of a surgical fellow in an university colorectal unit. Surg Endosc **23**, 1603-1608, 2009.

44) **Schlachta CM, Mamazza J, Seshadri PA, et al.**: Defining a learning curve for laparoscopic colorectal resections. Dis Colon Rectum **44**, 217-222, 2001.

45) **Hasegawa Y, Wakabayashi G, Nitta H, et al.**: A novel model for prediction of pure laparoscopic liver resection surgical difficulty. Surg Endosc **31**, 5356-5363, 2017.

46) **Ban D, Tanabe M, Ito H, et al.**: A novel difficulty scoring system for laparoscopic liver resection. J Hepatobiliary Pancreat Sci **21**, 745-753, 2014.

47) **Matsumoto M, Abe K, Futagawa Y, et al.**: New scoring system for prediction of surgical difficulty during laparoscopic cholecystectomy after percutaneous transhepatic gallbladder drainage. Ann Gastroenterol Surg **6**, 296-306, 2022.

48) **Nassar AHM, Hodson J, Ng HJ, et al.**: Predicting the difficult laparoscopic cholecystectomy: development and validation of a pre-operative risk score using an objective operative difficulty grading system. Surg Endosc **34**, 4549-4561, 2020.

49) **Gupta N, Ranjan G, Arora MP, et al.**: Validation of a scoring system to predict difficult laparoscopic cholecystectomy. Int J Surg **11**, 1002-1006, 2013.

50) **Veenhof AA, Engel AF, van der Peet DL, et al.**: Technical difficulty grade score for the laparoscopic approach of rectal cancer: a single institution pilot study. Int J Colorectal Dis **23**, 469-475, 2008.

51) **Krizzuk D, Yellinek S, Parlade A, et al.**: A simple difficulty scoring system for laparoscopic total mesorectal excision. Tech Coloproctol **24**, 1137–1143, 2020.

52) **Jamali FR, Soweid AM, Dimassi H, et al.**: Evaluating the degree of difficulty of laparoscopic colorectal surgery. Arch Surg **143**, 762-767, 2008.

53) **Schlachta CM, Mamazza J, Seshadri PA, et al.**: Predicting conversion to open surgery in laparoscopic colorectal resections. A simple clinical model. Surg Endosc **14**, 1114-1117, 2000.

54) **Tekkis PP, Senagore AJ** and **Delaney CP**: Conversion rates in laparoscopic colorectal surgery: a predictive model with, 1253 patients. Surg Endosc **19**, 47-54, 2005.

岩手医誌 75 巻，3 号（令和 5 年 8 月）81-94 頁.

腹腔鏡下大腸癌手術における
適切な症例選択のための新規スコアリングシステム

有吉　佑[1)]，大塚幸喜[2)]，八重樫瑞典[1)]，
高清水清治[1)]，畑中智貴[1)]，中村侑哉[1)]，
佐々木智子[1)]，高橋史朗[3)]，佐々木章[1)]

[1)] 岩手医科大学医学部，外科学講座
[2)] 藤田医科大学医学部，先端ロボット・内視鏡手術学講座
[3)] 岩手医科大学教養教育センター，情報科学科

(Received on January 10, 2023 & Accepted on January 20, 2023)

要旨

腹腔鏡下大腸癌手術の習得過程で，経験の浅い外科医は適切な症例選択が必要である．しかし，その手術難易度を予測する指標はほとんどない．当院で施行した腹腔鏡下大腸癌手術 1390 例を検討し，手術難易度を予測するスコアリングシステムを構築した．手術難易度の指標を手術時間とし，難易度に関連する因子を多変量解析で同定し，線形回帰分析を用いてスコア化した．

性別，body mass index > 25 kg/m^2，腫瘍占拠部位により手術難易度が決定され，これを 3 群に分類した．高難易度群では低・中難易度群に比べて手術時間や入院期間が長く，出血量が多く，合併症が多かった．構築したスコアリングシステムの整合性は ten-fold cross-validation により確認した．

構築したスコアリングシステムは腹腔鏡下大腸癌手術の手術難易度を予測することが可能であり，適切な手術症例の選択に有用であると思われる．