International Journal of Surgery Open 21 (2019) 52–57

Contents lists available at ScienceDirect

International Journal of Surgery Open

journal homepage: www.elsevier.com/locate/ijso

Case Report

# What is the optimal risk scoring for predicting complications after colorectal surgery in elderly patients?

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ARTICLE INFO

*Article history:*
Received 6 July 2019
Received in revised form
8 November 2019
Accepted 13 November 2019
Available online 19 November 2019

*Keywords:*
Risk scoring
Elderly patient
Colorectal cancer

ABSTRACT

*Background:* Although several risk scoring systems that predict postoperative complication incidence are available, the optimal scoring tool for elderly colorectal cancer patients remains unknown.
*Material and Methods:* Records of 659 patients underwent surgery for colorectal cancer were retrospectively reviewed, and 130 patients aged >80 years were divided into two groups according to postoperative complications (Clavien-Dindo classification ≥ grade II) as Complication group and Non-complication group.Scoring systems such as the Surgical Apgar score (SAS), and the Prognostic nutritional index (PNI), and sections of the Physiological and operative severity score for the enumeration of mortality and morbidity (POSSUM; physiological score (PS-P), and operative severity score (OS-P)), the Colorectal POSSUM (CR-POSSUM; physiological score (PS-CP) and operative severity score (OS-CP)), and Estimating the physiologic ability and surgical stress score (E-PASS; preoperative risk score (PRS), surgical stress score (SSS) and comprehensive risk score (CRS)) were analyzed.
*Results:* The PS-P, PRS, and CRS were significantly different between the two groups in univariate analysis. Area under the Receiver Operating Characteristic Curve of PRS was the highest among the scoring systems. Multivariate analysis also showed PRS was a useful risk scoring tool.
*Conclusions:* PRS may be useful for predicting the occurrence of complications for colorectal cancer in elderly patients.


## 1. Introduction

Colorectal cancer is one of the common gastrointestinal cancers in many developed countries and the incidence of colorectal cancer is expected to increase by 60% by 2030 [1]. In these countries, greater population aging has led to an increase in the number of elderly patients who require surgical intervention. Elderly patients usually have more comorbidities than younger patients, and are, therefore, regarded as high-risk patients for colorectal surgery [2]. In fact, some studies have reported that postoperative morbidity and mortality are higher in elderly patients [3–5], and postoperative complications are known to result in poor prognosis [6–8]. Therefore, predicting postoperative complications is required. Various risk scoring tools have been developed, such as Physiological and operative severity score for the enumeration of mortality and morbidity (POSSUM) [9], Colorectal POSSUM (CR-POSSUM) [10], Estimating the physiologic ability and surgical stress (E-PASS) [11], Surgical Apgar score (SAS) [12], and Prognostic nutritional index (PNI) [13].

POSSUM was developed in 1991 for general surgery and it calculates a Physiological score (PS) and an Operative Severity score (OS) using 12 preoperative physiological variables and 6 operative variables; these scores are used to calculate predictive mortality rate and complication rate. However, some studies have reported that this model overestimates mortality rate, especially in low-risk patients [14,15]. The CR-POSSUM is a modified version of the POSSUM and has been proposed for use among patients who undergo elective colorectal surgery. This tool requires only 6 physiological variables and 4 operative parameters to calculate PS and OS, and is therefore, not as complicated as POSSUM. E-PASS was also developed to predict mortality and morbidity and first validated in Japanese patients. E-PASS consists of 3 scores, including Preoperative risk score (PRS), Surgical stress score (SSS), and

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https://doi.org/10.1016/j.ijso.2019.11.007

Comprehensive risk score (CRS) and these are calculated using parameters that assess health status and surgical stress. SAS is a representative risk assessment tool that scores postoperative morbidities and is calculated based on intraoperative parameters such as blood pressure and estimated blood loss. PNI was first reported by Onodera et al. and it is calculated based on serum albumin and lymphocyte counts, which assess surgical risk specific for gastrointestinal surgery.

Despite the presence of multiple scoring tools, it remains uncertain which tool is most suitable for elderly patients undergoing colorectal surgery. Thus, the aim of this study was to compare multiple risk scoring tools to identify the optimal tool for use in patients older than 80 years who undergo surgery for colorectal cancer.

## 2. Methods

Medical records of 659 consecutive patients who underwent either laparoscopic colorectal surgery or open colorectal surgery for colorectal cancer between 2011 and 2017 were reviewed retrospectively. Patients who met at least one of the following conditions were excluded from our study (n = 49), namely, double primary colorectal cancer, colorectal cancer with other gastrointestinal cancer, emergency procedure for obstruction caused by colorectal cancer, total pelvic exenteration, familial adenomatous polyposis, or appendix cancer.

All patients underwent the standard radical procedure recommended by the Japanese Classification of Colorectal Carcinoma (8th edition) [16], except those who underwent palliative partial resection. Intestinal excision with lymph node dissection was performed to separate the tumor feeding vessel. All patients who were diagnosed with extramural invasion on CT scan underwent open colorectal surgery; else, the choice of surgical approach was made collectively by the surgeon and the patient after the benefits and risks of all approaches were explained.

Patients who underwent conversion to open colorectal surgery were categorized as open colorectal surgery and conversion to open colorectal surgery was defined as an unplanned incision longer than 8 cm that was performed during the laparoscopic procedure. At least one board-certified surgeon (Japan Surgical Society) participated in all procedures.

Here, patients over 80 years of age were defined as elderly patients and we used data from 130 eligible patients (Fig. 1). The complication group comprised cases with complication ≥ grade II according to the Clavien-Dindo classification, and the 130 elderly patients were divided into two groups based on the incidence of postoperative complication as the Complication group (C group) and the Non-complication group (NC group). Physiological score (PS–P) and Operative severity score (OS–P) from POSSUM, Physiological score (PS-CP) and Operative severity score (OS-CP) from CR-POSSUM, Preoperative risk score (PRS), Surgical stress score (SSS), and comprehensive risk score (CRS) from E-PASS, SAS, and PNI were computed and compared between the two groups.

Data for computing the scores, demographic data, and detailed history were extracted from medical records and analyzed and include age, gender, body mass index (BMI), performance status (Eastern Cooperative Oncology Group), American society of anesthesiologists physical status classification (ASA-PS), preoperative comorbidity, surgical procedure type, procedure duration, blood loss, number of harvested lymph nodes, curative procedures, pathological stage (Japanese Classification of Colorectal Carcinoma), postoperative complications, and length of postoperative hospital stay. Severe pulmonary disease was defined as vital capacity less than 60% and/or forced expiratory volume less than 50%.

Data are presented as mean ± standard error of mean. In univariate analysis, categorical variables were analyzed using the chi-square test, whereas continuous data were analyzed using either the two-tailed Student's *t*-test or the Wilcoxon test, based on the results of the Shapiro–Wilk test. Multivariate analysis was performed with logistic regression analysis. Statistical significance was defined as $p < 0.05$. The optimal cutoff value was calculated using the receiver operating characteristic (ROC) curve and was defined as the number that indicated the highest sum of sensitivity and specificity on the ROC curve. All statistical analyses were performed using JMP Pro 11 (SAS Institute, Cary, NC, USA). This work was reported in line with STROCSS criteria [17].

## 3. Results

Among 130 patients included in this study, 27 patients were categorized under group C while 103 patients were in group NC. No patient needed conversion to open colorectal surgery during the laparoscopic procedure. With respect to preoperative characteristics, number of patients with performance status 4 was greater in C group than in the NC group (7.4% vs. 1.0%; $p = 0.0047$) and as were patients with ASA-PS-3 (48.2% vs. 27.2%; $p = 0.037$; Table 1). In terms of comorbidities, the overall comorbidity rate in C group was 85.2% and that in the NC group was 85.3% (Table 2). Severe pulmonary disease (18.5% vs. 3.9%; $p = 0.008$) and renal dysfunction (14.8% vs. 1.9%; $p = 0.0045$) were higher in group C than in group NC. In contrast, there was no difference in cardiovascular comorbidity, which is an important category in some risk scores such as PS-P, PS-CP, PRS, and SAS. Importantly, there was no difference in the number of patients whose NYHA was grade ≥ III between the two groups.

Table 3 lists operative procedures, and surgical and pathological findings. With respect to surgical procedure details there were no significant differences and there was no difference in the

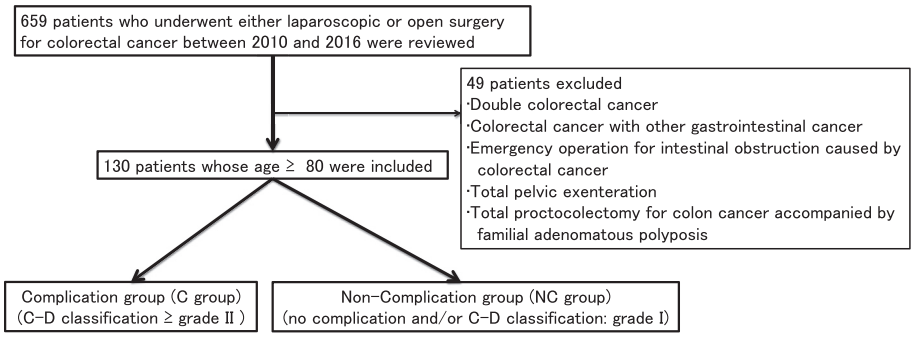


**Fig. 1.** Study flow chart. C-D classification: Clavien-Dindo classification.

**Table 1**
Preoperative patients' characteristics.

| Variables | C group | NC group | p value |
|---|---|---|---|
| | n = 27 | n = 103 | |
| Age, years | 85.0 ± 0.663 | 84.0 ± 0.34 | 0.162 |
| Male, n (%) | 12 (44.4) | 42 (40.8) | 0.731 |
| BMI, kg/m$^2$ | 22.8 ± 0.767 | 22.1 ± 0.393 | 0.41 |
| PS (ECOG), n (%) | | | |
| 0/1/2 | 19 (70.4) | 82 (79.6) | 0.305 |
| 3 | 6 (22.2) | 20 (19.4) | 0.746 |
| 4 | 2 (7.4) | 1 (1.0) | 0.047 |
| ASA-PS, n (%) | | | |
| 0/1/2 | 14 (51.9) | 75 (72.8) | 0.037 |
| 3 | 13 (48.2) | 28 (27.2) | 0.037 |
| ≥4 | 0 (0) | 0 (0) | – |
| Location of tumor, n (%) | | | |
| Colon | 19 (70.4) | 86 (83.5) | 0.124 |
| Rectum | 8 (29.6) | 17 (29.6) | |

BMI: Body mass index.
PS: Performance status.
ECOG: Eastern Cooperative Oncology Group.
ASA-PS: American society of anesthesiologists physical status.

**Table 2**
Preoperative comorbidities.

| Variables | C group | NC group | P value |
|---|---|---|---|
| | n = 27 | n = 103 | |
| Overall comorbidity, n (%) | 23 (85.2) | 86 (83.5) | 0.832 |
| Cardiovascular, n (%) | 9 (33.3) | 21 (20.4) | 0.155 |
| NYHA stage | | | |
| ≥ Class III, n (%) | 2 (7.4) | 3 (2.9) | 0.28 |
| Respiratory, n (%) | 3 (11.1) | 21 (20.4) | 0.269 |
| Severe pulmonary disease, n (%) | 5 (18.5) | 4 (3.9) | 0.008 |
| Cerebrovascular, n (%) | 4 (14.8) | 11 (10.7) | 0.549 |
| Hepatic, n (%) | 1 (3.7) | 1 (1.0) | 0.304 |
| Renal, n (%) | 4 (14.8) | 2 (1.9) | 0.0045 |
| Hypertension, n (%) | 21 (77.8) | 77 (74.8) | 0.746 |
| Diabetes, n (%) | 7 (25.9) | 18 (17.5) | 0.321 |
| Anticoagulant therapy, n (%) | 5 (18.5) | 19 (18.5) | 0.993 |
| Chronic steroid use, n (%) | 1 (3.7) | 5 (4.9) | 0.799 |

NYHA: New York heart association

proportion of patients who underwent laparoscopic colorectal surgery. Operating times in the C group were longer than those in the NC group (219 ± 10.7 vs. 193 ± 5.5 min; $p = 0.035$); however, there was no difference in blood loss. Regarding pathological findings, although there was no difference in the prevalence of advanced tumor, patients at stage 0 were greater in the C group compared to the NC group (7.4% vs. 4.9%; $p = 0.0047$).

Table 4 provides details on postoperative complications. In the C group, the most frequent complication was postoperative ileus (48.2%), while anastomotic leakage occurred in 3 patients (11.1%). Further, there was one patient (age 93 y) who had undergone a right colectomy and whose Clavien-Dindo classification was grade V due to septic shock after anastomotic leakage. Postoperative hospital stay duration was significantly longer in the C group than in the NC group (32.8 ± 2.23 vs. 13.0 ± 1.14 days; $p = <0.0001$).

The results of univariate analysis for risk factors are shown in Table 5. Significant differences between the two groups were seen in PS-P (26.4 ± 1.16 vs. 23.7 ± 0.593; $p = 0.04$), PRS (0.77 ± 0.038 vs. 0.651 ± 0.019; $p = 0.0056$) and CRS (0.511 ± 0.050 vs. 0.340 ± 0.026; $p = 0.0031$) scores. Fig. 2 shows ROC curve of PS-P, PRS, and CRS. The area under the curve (AUC) of PRS was the greatest among the three scores. As CRS has an obvious relation with PRS, therefore, we performed multivariate analysis using PS-P and PRS. The resultant ROC curve analysis yielded a value of 24 as the optimal cutoff for PS-P, whereas a value of 0.659 was the optimal cutoff for PRS. Based on these cutoff values, multivariate analysis showed that PRS >0.659 [odds ratio (OR), 3.33; 95% confidence interval (CI), 1.182–9.407; $p = 0.023$] was an independent risk factor for the incidence of postoperative complication (Table 6).

## 4. Discussion

In this study, the incidence of postoperative complications was 42.3% and the proportion of patients whose Clavien-Dindo classification was ≥ II was 20.8%. The mortality rate was 0.77%. These results are comparable to those in previous reports [18,20].

In developed countries, as population aging increases, the number of elderly patients aged 80 y or older is also rising. Elderly patients also have more comorbidities compared to younger patients, and are, therefore, regarded as high risk patients for colorectal surgery [2]. In fact, previous studies have shown that mortality and morbidity after colorectal surgery increased with increasing age, male gender, and greater comorbidities [4,21,22]. Even though, advanced techniques in surgery and anesthesia have helped reduce risk of surgery; the indications for colorectal surgery have been expanded, and consequently, more elderly patients with

**Table 3**
Operative procedures and surgical/pathological findings.

| Variables | C group | NC group | p value |
|---|---|---|---|
| | n = 27 | n = 103 | |
| Operative procedures | | | |
| Right colectomy/Ileocecal resection, n (%) | 10 (37.0) | 58 (56.3) | 0.074 |
| Transverse colectomy, n (%) | 1 (3.7) | 10 (9.7) | 0.318 |
| Left colectomy/Sigmoidectomy, n (%) | 7 (25.9) | 14 (13.6) | 0.121 |
| High anterior resection, n (%) | 5 (18.5) | 8 (7.8) | 0.097 |
| Low anterior resection, n (%) | 2 (7.4) | 8 (7.8) | 0.95 |
| Hartmann operation/Miles' operation, n (%) | 2 (5.4) | 5 (4.9) | 0.601 |
| Laparoscopy assisted colorectal surgery, n (%) | 8 (29.6) | 37 (35.9) | 0.541 |
| Surgical and pathological findings | | | |
| Operating time, min | 219 ± 10.7 | 193 ± 5.5 | 0.035 |
| Blood loss, ml | 204 ± 37.5 | 178 ± 19.2 | 0.531 |
| Number of harvested lymph nodes | 16.5 ± 2.45 | 21.0 ± 1.25 | 0.105 |
| UICC 7th disease stage, n (%) | | | |
| 0 | 2 (7.4) | 5 (4.9) | 0.0047 |
| I | 3 (11.1) | 22 (21.4) | 0.229 |
| II | 12 (44.4) | 37 (35.9) | 0.416 |
| III | 8 (29.3) | 32 (31.1) | 0.885 |
| IV | 2 (7.4) | 7 (6.8) | 0.911 |

UICC: Union for international cancer control.

**Table 4**
Postoperative outcomes.

| Variables | C group | NC group | P value |
|---|---|---|---|
| | n = 27 | n = 103 | |
| Postoperative complications | | | |
| Surgical site infection, n (%) | 5 (18.5) | 11 (10.7) | 0.012 |
| Postoperative ileus | 13 (48.2) | 10 (9.7) | <.0001 |
| Anastomotic leakage | 3 (11.1) | 0 (0) | 0.0006 |
| Intraabdominal abscess | 2 (7.4) | 0 (0) | 0.0054 |
| Postoperative bleeding | 1 (3.7) | 0 (0) | 0.049 |
| Respiratory complication | 2 (7.4) | 1 (1.0) | 0.047 |
| Cardiovascular complication | 2 (7.4) | 0 (0) | 0.011 |
| Renal dysfunction | 2 (7.4) | 0 (0) | 0.0054 |
| Deep vein thrombosis | 2 (7.4) | 0 (0) | 0.011 |
| Colitis | 3 (11.1) | 1 (1.0) | 0.158 |
| Clavien-Dindo classification | | | |
| I | 0 (0) | 28 (27.2) | 0.0022 |
| II | 17 (63.0) | 0 (0) | <.0001 |
| IIIa | 5 (18.5) | 0 (0) | <.0001 |
| IIIb | 1 (3.7) | 0 (0) | 0.049 |
| IVa | 2 (7.4) | 0 (0) | 0.0054 |
| IVb | 1 (3.7) | 0 (0) | 0.049 |
| V | 1 (3.7) | 0 (0) | 0.049 |
| Postoperative hospital stay, days | 32.8 ± 2.23 | 13.0 ± 1.14 | <.0001 |

**Table 5**
Univariate analysis of risk scorings.

| Variables | C group | NC group | P value |
|---|---|---|---|
| | n = 27 | n = 103 | |
| PS-P | 26.4 ± 1.16 | 23.7 ± 0.593 | 0.04 |
| OS-P | 12.0 ± 0.376 | 11.7 ± 0.193 | 0.595 |
| PS-CP | 14.3 ± 0.335 | 13.8 ± 0.171 | 0.272 |
| OS-CP | 7.44 ± 0.12 | 0.745 ± 0.062 | 0.987 |
| PRS | 0.77 ± 0.038 | 0.651 ± 0.019 | 0.0056 |
| SSS | 0.122 ± 0.038 | 0.061 ± 0.019 | 0.15 |
| CRS | 0.511 ± 0.050 | 0.34 ± 0.026 | 0.003 |
| SAS | 7.78 ± 0.246 | 7.36 ± 0.126 | 0.132 |
| PNI | 43.8 ± 1.57 | 44.4 ± 0.804 | 0.747 |

PS-P: Physiological score in POSSUM.
OS-P: Operative severity score in POSSUM.
PS-CP: Physiological score in CR-POSSUM.
OS-CP: Operative severity score in CR-POSSUM.
PRS: Preoperative risk score in E-PASS score.
SSS: Surgical stress score in E-PASS score.
CRS: Comprehensive risk score in E-PASS score.
SAS: Surgical apgar score.
PNI: Prognostic nutritional index.

poor health undergo colorectal surgery. Thus, more accurate methods of risk scoring are necessary to accurately predict postoperative morbidity.

**Table 6**
Multivariate logistic analysis of risk scorings.

| Variables | AUC | Cut-off value | Incidence (%) | OR | 95% CI | p value |
|---|---|---|---|---|---|---|
| PS-P | 0.631 | ≥24 | 19 (29.7) | 2.31 | 0.864–6.191 | 0.095 |
| | | <24 | 8 (12.1) | | | |
| PRS | 0.678 | ≥0.659 | 17 (36.2) | 3.33 | 1.182–9.407 | 0.023 |
| | | <0.659 | 10 (12.1) | | | |

AUC: Aria under the curve.
OR: Odds ratio.
95% CI: 95% Confidence interval.
PS-P: Physiological score in POSSUM.
PRS: Preoperative risk score in E-PASS score.

Although several studies have reported on tools for optimal risk scoring in colorectal surgery for elderly patients [23–26], the definition of the elderly patient was different in these studies. To the best of our knowledge, this is the first report on optimal risk scoring among octogenarians undergoing surgery for colorectal cancer. Additionally, in previous studies, patients with overall postoperative comorbidities, including Clavien-Dindo classification grade I, were categorized as part of the complication group [23,24,26]. However, as complications associated with Clavien-Dindo classification grade I have very little influence on postoperative hospital stay, we have defined the C-group as complication ≥ grade II, based on the Clavien-Dindo classification.

In this study, PRS was the most useful risk scoring tool. Preoperatively, PS, ASA-PS, severe pulmonary disease, and renal dysfunction were different between the two groups, and all these four categories are included in the PRS score. PS-P was significantly different only during univariate analysis and one of the reasons for why it had less AUC than PRS may be due to the fact that PS and ASA-PS are not needed to calculate PS-P. As we can calculate PRS preoperatively, this risk scoring is useful for deciding on whether to perform surgery in octogenarian patients.

Previous studies have also shown that CRS is an optimal risk scoring tool [25,26]. Given that CRS is calculated using PRS and SSS scores, we show that CRS is not an optimal risk scoring tool in this study because SSS was not significantly different between the two groups. Although SSS incorporates blood loss, operating time, and the extent of skin incision, only operating time was different among these three categories. E-PASS score has been proposed to predict morbidity and mortality after general surgery; however, almost all colorectal surgery does not involve much bleeding and does not require large procedure durations compared to more invasive surgery such as liver resection or pancreatectomy. Accordingly, there was little difference in SSS between the two groups undergoing colorectal surgery. Recently, some studies have reported on the better safety profile of laparoscopic colorectal surgery in elderly patients [18,19]. Therefore, it is expected that elderly patients

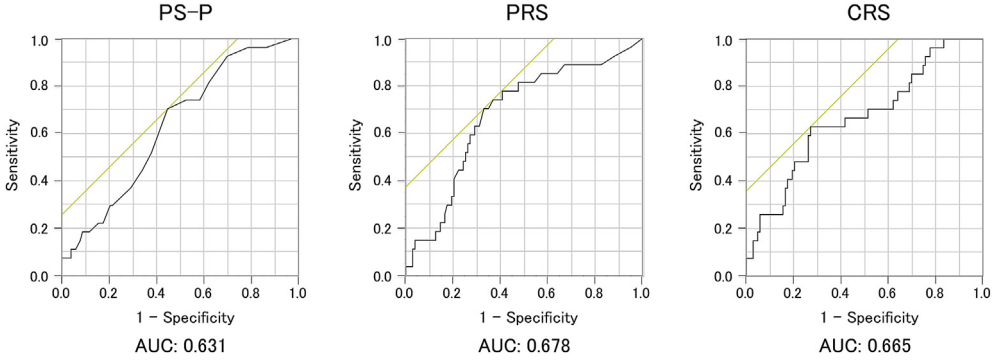


**Fig. 2.** Receiver Operating Characteristic curve for postoperative complication. PS-P: Physiological score in POSSUM. PRS: Preoperative risk score in E-PASS score. CRS: Comprehensive risk score in E-PASS score. AUC: Aria under the curve.

would undergo laparoscopic surgery. Further, as the laparoscopic surgery uses only a small incision with minimal blood loss, SSS scores are expected to decrease further in the future, and consequently, the impact of SSS scores on CRS will be smaller.

SAS incorporates intraoperative parameters such as blood pressure and estimated blood loss [12]. However, as there was no difference in cardiovascular comorbidity between the two groups, it may not have significantly affected blood pressure. Additionally, blood loss was also not different between the two groups. Therefore, there was no difference in SAS scores between the two groups. PNI is calculated using serum albumin concentration and lymphocyte count [13] and is a useful parameter of immune and nutritional status. Tokunaga et al. have reported that PNI is an independent risk factor of postoperative complications in colorectal surgery [27]. However, patients enrolled in this study were octogenarians and most octogenarians are expected to have poor nutritional and immune status; thus, there would be trivial difference in PNI scores.

There are some limitations to this study. First, our study was retrospective and had a relatively small sample size. Therefore, further prospective studies with large patient numbers are required. Second, this is a single institution study and the results may not be generalizable to other hospitals. Third, there was a selection bias as the decision of on surgical procedure was made by the attending surgeon; and some patients underwent a Hartman procedure to prevent anastomotic leakage even if they could undergo a low anterior resection.

In conclusion, PRS can be a useful risk scoring tool for predicting the occurrence of complications among elderly patients undergoing surgery for colorectal cancer. Furthermore, PRS over 0.659 was an independent risk factor of postoperative complications, and as PRS can be calculated preoperatively, PRS scores might guide decisions on whether to perform surgery or not.

## Ethics approval

This study protocol was reviewed and approved by the Ethics Committee of the South Miyagi Medical Center on May 22, 2018. Registration number: 18-1

Informed consent was waived by the Ethics Committee of the South Miyagi Medical Center.

## Funding

None.

## Author contribution

KI wrote this paper and contributed to the conception of the study, critically revised the work for important intellectual content, and approved the version to be published. KI also agreed to be accountable for all aspects of the work and for ensuring that questions related to the accuracy and integrity of any part of the work were appropriately investigated and resolved.

TU contributed to the conception of the study, critically revised the work for important intellectual content, and approved the version to be published. TU also agreed to be accountable for all aspects of the work and for ensuring that questions related to the accuracy and integrity of any part of the work were appropriately investigated and resolved.

NA contributed to collect medical record and also contributed to draft work.

TS contributed to collect medical records and also contributed to draft work.

TT contributed to the design of the work, drafted the work, and approved the version to be published. TT also agreed to be accountable for all aspects of the work and for ensuring that questions related to the accuracy of any part of the work were appropriately investigated and resolved.

SN contributed to the design of the work and drafted the work.

KS contributed to the design of the work and drafted the work. KS also approved the version to be published and agreed to be accountable for all aspects of the work and for ensuring that questions related to the accuracy of any part of the work were appropriately investigated and resolved.

SG contributed to the design of the work and drafted the work. SG also approved the version to be published and agreed to be accountable for all aspects of the work and for ensuring that questions related to the accuracy of any part of the work were appropriately investigated and resolved.

MT contributed to the design of the work and drafted the work. MT also approved the version to be published and agreed to be accountable for all aspects of the work and for ensuring that questions related to the accuracy of any part of the work were appropriately investigated and resolved.

TN contributed to the conception of the study, critically revised the work for important intellectual content, and approved the version to be published.

HN contributed to the conception and critically revised the work for important intellectual content. HN also approved the version to be published and agreed to be accountable for all aspects of the work and for ensuring that questions related to the accuracy and integrity of any part of the work were appropriately investigated and resolved.

## Conflict of interest statement

None.

## Guarantor

Koetsu Inoue.
Tatsuya Ueno.

## Research Registration Number

None.

## Acknowledgements

The authors would like to thank Enago (www.enago.jp) for the English language review.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijso.2019.11.007.

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