## <u>Original Research</u>

# Association Between Peritoneal Carcinomatosis Index (PCI) Assessed by CT and Pathological Parameters and Short-Term Prognosis of Rectal Cancer

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#### ABSTRACT

**Objective** • The study aimed at explore the correlation between the CT-based Peritoneal Carcinomatosis Index (PCI) and pathological parameters of rectal cancer, as well as the correlation with short-term postoperative prognosis. **Methods** • A retrospective analysis was performed on 198 rectal cancer patients treated in our institution from January 2017 to December 2022. Based on preoperative CT-PCI, patients were classified into a normal and low CT-PCI groups. Baseline characteristics and short-term postoperative outcomes were compared between the two groups. Univariate and Multivariable logistic regression analyses were conducted to ascertain the independent risk factors for postoperative complications (Clavien-Dindo classification  $\geq$  Grade II) following neoadjuvant treatment and radical rectal cancer surgery.

**Results** • There were significant statistical differences between the two groups regarding age, ASA score, and surgical method (P < .05). Variations in overall postoperative complications and complications of Grade II or higher among patients with differing preoperative

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#### INTRODUCTION

Rectal cancer represents a prevalent malignant tumor within the digestive system. Its incidence has seen a marked rise in recent years, attributed to Factors including erratic CT-PCI were statistically significant (P < .05). No significant statistical difference was found in the time to first liquid intake post-surgery between the preoperative low CT-PCI group and the normal CT-PCI group (P > .05); however, differences in the time to first flatus, duration of postoperative hospital stay, and total hospital expenditure were statistically meaningful (P < .05). Multivariate logistic regression revealed that CT-PCI (OR=2.254) was an influential factor for postoperative complications (Clavien-Dindo classification  $\geq$  Grade II) (P < .05). The ROC curve demonstrated an AUC of 0.854 for CT-PCI in predicting postoperative complications (Clavien-Dindo classification  $\geq$  Grade II).

**Conclusion** • Preoperative CT-PCI may be utilized to evaluate the short-term prognosis of patients who undergo radical surgery for rectal cancer after neoadjuvant therapy. This evaluation assists in guiding clinical diagnostic and therapeutic decision-making, allowing for prompt interventions and enhancing short-term patient outcomes. (*Altern Ther Health Med.* 2024;30(12):269-273).

lifestyles and alterations in dietary habits.<sup>1</sup> Often, the early phases of rectal cancer are characterized by an lack of specific clinical symptoms, leading to oversight by patients. By the time conspicuous symptoms like rectal bleeding manifest, the disease generally reaches an advanced stage, thereby missing the window for optimal therapeutic intervention.<sup>2</sup> Hence, a timely and precise diagnosis, combined with accurate assessment of both the condition and prognosis of rectal cancer patients, holds substantial significance in reducing mortality rates. The Peritoneal Cancer Index (PCI) score, ascertainable through laparoscopic procedures, diagnostic laparoscopy, open surgery, or various imaging techniques, is utilized in the clinical setting to gauge peritoneal dissemination in diverse conditions, including gastric cancer, colorectal tumors, peritoneal mesothelioma, ovarian epithelial cancer, and primary peritoneal cancer.<sup>3-5</sup> PCI research leverages imaging modalities such as ultrasound, CT, MRI, and PET-CT. Due to its concise duration and

comparatively modest cost, CT remains the primary as the principal preoperative imaging technique for tumors.<sup>6,7</sup> The focus of this study is to investigate the potential of CT-PCI as a non-invasive modality in determining its correlation with the pathological parameters and short-term postoperative prognosis of rectal cancer, thereby facilitating clinical decision-making in treatment strategies.

## SUBJECTS AND METHODS

#### **Research Subjects**

A retrospective evaluation was performed on 198 cases of rectal cancer patients who underwent treatment at our institution between January 2017 and December 2022. All the subjects met the following inclusion criteria: (1) Individuals who were newly diagnosed with rectal cancer, confirmed through postoperative pathological examination, and provided with comprehensive clinical, surgical, and pathological information; (2) The availability of preoperative full abdominal CT scans, both plain and enhanced, within our facility, accompanied by quality-enhanced portal venous phase imagery; (3) The chosen method of treatment was radical surgery specific to rectal cancer; (4) The time gap between preoperative CT scanning and the actual surgery was constrained to a maximum of 2 weeks; (5) Absence of prior malignant tumor history; (6) A postoperative follow-up duration extending beyond 1 month. Exclusion criteria encompassed: (1) Those who had previously undergone radical surgery for rectal cancer; (2) A deficiency in requisite clinical and pathological documentation; (3) Demise either during the hospital stay or within a 30-day window postdischarge. This investigation complied with the ethical guidelines delineated by the hospital's ethics committee.

#### Gathering of Clinical and Pathological Information

(1) Clinical Baseline Metrics: Factors such as age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) grading, tumor dimensions, tumor positioning, differentiation levels, surgical approach, neoadjuvant treatment strategy, response to neoadjuvant therapy, clinical T classification, clinical N categorization, and pathological TNM staging; (2) Surgical Parameters: Variables including the duration of the surgical procedure, volume of hemorrhage, and related considerations; (3) Indicators Pertaining to Postoperative Recovery: The incidence of complications following surgery, initial passage of flatus postoperatively, initiation of liquid intake subsequent to surgery, length of postoperative hospitalization, and aggregate hospital expenditure.

## **Definition of Related Metrics**

Postoperative complications are defined as those arising within a 30-day period following the surgery. The Clavien-Dindo classification is adopted to grade these complications into five levels.<sup>8</sup> Two investigators independently analyze and statistically evaluate the incidence of postoperative complications for each patient. If discrepancies arise, a final conclusion is reached through discussion. The reaction to neoadjuvant therapy is assessed in accordance with tumor regression grading (TRG),<sup>9</sup> stratifying patients into those exhibiting a favorable response to treatment and those demonstrating an inadequate response. A favorable response corresponds to TRG 2-3, whereas an inadequate response is designated as TRG 0-2b.

#### Methodology for Preoperative CT-PCI Evaluation

**CT** Examination Procedure: Of the 198 patients examined, 117 were scanned utilizing Siemens SOMATOM Definition 64-slice spiral CT, 51 with Philips Brilliance16-slice spiral CT, and 30 via Siemens Emotion 6-slice spiral CT. The scanning area encompassed the top of the diaphragm to the lower plane of the pubic symphysis, set at a tube voltage of 120 kV and tube current ranging between 252 and 313 mA. The scan had a thickness of 5 mm, employing volumetric scanning, with a reconstruction layer thickness and interval uniformly at 2.5 mm. The portal venous phase scanning was conducted approximately 70 seconds post-contrast injection.

**CT Image Interpretation**: The CT images underwent randomized analysis by two physicians, one with 5 years and the other with 8 years of diagnostic radiology experience, both blind to the surgical details and pathological findings. The CT-PCI rating was computed in accordance with the cumulative Sugarbaker scores, fundamentally dividing the abdomen into 13 zones: 0-central, 1-right upper abdomen, 2-lesser omentum sac, 3-left upper abdomen, 4-left lateral abdomen, 5-left iliac region, 6-pelvis, 7-right iliac region, 8-right lateral abdomen, 9-upper jejunum, 10-lower jejunum, 11-upper ileum, 12-lower ileum. The scoring was assigned as follows: 0 for no tumor, 1 for tumors smaller than 0.5 cm, 2 for tumors ranging from 0.5 to 5 cm (inclusive), and 3 for tumors larger than 5 cm or amalgamated lesions. The PCI score range spanned approximately from 0 to 39 points.<sup>3</sup>

#### **Statistical Analysis**

The experimental data of this study were analyzed using Statistic Package for Social Science (SPSS) 27.0 (IBM, Armonk, NY, USA). For quantitative data following a normal distribution, the representation was given by  $\overline{x \pm s}$ , and the paired t-test was used to compare two groups. Categorical data were delineated as case numbers or rates, and the  $\chi^2$  test was utilized for intergroup comparisons. Those factors demonstrating statistical significance in the univariate analysis were incorporated into a multivariate analysis employing the Logistic regression model. The predictive value of relevant factors concerning short-term prognosis was assessed via the receiver operating characteristic (ROC) curve, with P < .05 being considered statistically significant.

## RESULTS

## ROC Curve Analysis for Predicting Postoperative Complications Using Preoperative CT-PCI

A ROC curve was constructed based on the preoperative CT-PCI of patients and the occurrence of postoperative complications. The ROC curve reveals that preoperative **Figure 1.** ROC curve analysis of preoperative CT-PCI for predicting postoperative complications in patients.



CT-PCI has a moderate predictive ability for postoperative patient complications. The optimal cut-off value for preoperative CT-PCI was identified as 8, with a Youden's index of -0.392, and the area under the curve (AUC) amounted to 0.693, with a 95% confidence interval (CI) ranging from 0.543 to 0.837 (refer to Figure 1).

#### **Comparison of Baseline Indicators Between Two Groups**

According to the ROC curve cut-off value of 8, patients were categorized into the low CT-PCI group (62 cases) and the normal CT-PCI group (136 cases). The two groups had statistically significant differences in age, ASA score, and surgical approach (P < .05), as detailed in Table 1.

#### Comparison of Postoperative Complications Among Different Preoperative CT-PCI Groups

In the preoperative low CT-PCI group, 18 patients experienced postoperative complications, with 15 of them being grade II or above. In the preoperative normal CT-PCI group, 20 patients encountered postoperative complications, 17 of which were grade II or higher. There were statistically significant differences in overall postoperative complications and grade II or higher complications among the different preoperative CT-PCI groups (P < .05), as presented in Table 2.

#### Comparison of Postoperative Recovery Among Different Preoperative CT-PCI Groups

Compared to the preoperative normal CT-PCI group, the difference in the time to first intake of liquids post-surgery for patients with preoperative low CT-PCI group was not statistically significant (P > .05). There were statistically significant differences in the time to first flatus, the duration of postoperative hospital stay, and the total hospitalization cost between the two groups (P < .05), as illustrated in Table 3.

# **Table 1.** Comparison of Clinical Information Between theTwo Groups

	Low CT-PCI	Normal CT-PCI		
Variable	Group (62 cases)	Group (136 cases)	$t/\chi^2$ value	P value
Age (years)	68.94±7.34	66.37±8.32	2.089	.038
Gender				
Man	31	76	0.593	.441
Woman	31	60		
ASA Score				
I - II	40	112	7.597	.006
III - IV	22	24		
Tumor Diameter (cm)				
≤5	35	71	0.309	.579
> 5	27	65		
Distance to the analytical verge (cm)				
11-15	16	38	1.463	.481
6-10	24	41		
0-5	22	57		
Grade				
Well or moderate	52	115	0.015	.902
Poor or worse	10	21		
Surgical approach				
Open surgery	10	6	7.871	.005
Minimally invasive surgery	52	130		
Pathological TNM stage				
Ι	10	30	1.298	.523
II	33	62		
III	19	44		
Neoadjuvant treatment				
TNT	20	54	1.009	.315
CRT	42	82		
TRG				
Non responder (grade 0/1a/1b)	37	72	0.781	.377
Responder (grade 2/3)	25	64		

**Table 2.** Comparison of Postoperative Complications AmongDifferent Preoperative CT-PCI Groups

	Low CT-PCI	Normal CT-PCI		
Variable	Group (62 cases)	Group (136 cases)	$\chi^2$ value	P value
All complications	18	20	5.636	.018
Clavien-Dindo grade ≥ II	15	17	4.298	.038
Surgical site infection	5	7	0.637	.425
Ileus	2	5	0.025	.874
Leakage	3	4	0.450	.503
Intra-abdominal abscess	2	2	0.663	.416
Cardiovascular events	2	1	1.770	.183
Pneumonia	2	1	1.770	.183
Urinary infection	2	1	1.770	.183
Mortality	1	0	2.205	.138

**Table 3.** Comparison of Postoperative Recovery AmongDifferent Preoperative CT-PCI Groups

	Low CT-PCI	Normal CT-PCI		
Variable	Group (62 cases)	Group (136 cases)	t value	P value
Days to first flatus (d)	3.56±1.09	2.87±0.76	5.139	.000
Days to soft diet (d)	6.17±1.76	5.88±1.90	1.019	.310
Postoperative hospital stay (d)	11.87±2.98	9.36±2.57	6.057	.000
Total hospital expenditure (ten thousand yuan)	8.46±2.79	7.41±1.38	3.546	.000

**Table 4.** Multivariate Logistic Regression Analysis ofFactors Influencing

racioi D	value	SE value	Ward value	OR value	95%CI	P value
CT-PCI (actual value) 0	).813	0.365	4.958	2.254	1.102~4.609	.000

## Multivariate Logistic Regression Analysis of Factors Influencing Postoperative Complications (Clavien-Dindo Grade ≥ II)

A multivariate Logistic regression analysis was performed using variables with statistical significance from univariate analysis as independent variables, and taking CT-PCI as the dependent variable (No = 0, Yes = 1). The results indicated that CT-PCI (OR = 2.254) is a factor affecting postoperative complications (Clavien-Dindo Grade  $\geq$  II) (*P* < .05), as detailed in Table 4. **Table 5.** Analysis of CT-PCI's Predictive Value forPostoperative Complications (Clavien-Dindo Grade  $\geq$  II)

 Variable
 AUC
 95%CI
 Specificity
 Sensitivity

 CT-PCI
 0.854
 0.749~0.957
 83.24
 80.13

**Figure 2.** ROC Curve of CT-PCI Predicting Postoperative Complications (Clavien-Dindo Grade ≥ II)



## Predictive Value of CT-PCI for Postoperative Complications (Clavien-Dindo Grade ≥ II)

An ROC curve was plotted using CT-PCI as the predictive variable and the occurrence of postoperative complications (Clavien-Dindo Grade  $\geq$  II) as the actual value. The analysis indicated that the AUC (Area Under the Curve) for CT-PCI's prediction of postoperative complications (Clavien-Dindo Grade  $\geq$  II) was 0.854. Details can be found in Table 5 and Figure 2.

## DISCUSSION

Rectal cancer refers to a malignant tumor located at the junction between the rectum and the sigmoid colon, and it is closely associated with conditions such as ulcerative colitis, family genetic history, and poor dietary habits.<sup>10</sup> Surveys conducted in China have shown that the incidence and mortality rates of rectal cancer rank third and fifth, respectively, among malignant tumors, with a relatively higher incidence in the 40–50 age group.<sup>11,12</sup> The Peritoneal Cancer Index (PCI) serves as a crucial parameter for evaluating the size and distribution of the tumor, reflecting the extent and severity of the tumor's spread within the abdominal and pelvic cavities. Additionally, it is also as an independent factor related to prognosis.<sup>13-15</sup>

This study revealed statistically significant differences in overall postoperative complications and grade II or higher complications among patients with varying preoperative CT-PCI scores. These findings suggest that in rectal cancer patients, different preoperative CT-PCI scores may influence the occurrence rate and severity of postoperative complications, with higher CT-PCI scores possibly correlating with more severe intra-abdominal and pelvic tumor spread and, consequently a higher risk of complications.<sup>16</sup> Furthermore, the study identified significant differences between the two groups of patients in the time to first flatus, duration of postoperative hospital stay, and total hospital costs. This discovery implies that different preoperative CT-PCI grades may affect the surgical recovery and hospitalization conditions of rectal cancer patients. Higher CT-PCI grades might be linked to more intricate surgical procedures and postoperative recovery,<sup>17</sup> potentially leading to a longer time to first flatus, extended hospital stays, and increased overall costs. These findings hold essential guidance for patient postoperative management and the recovery process. Clinicians can leverage CT-PCI grading to foresee patients' postoperative recovery needs and prepare accordingly, enhancing patient recovery while minimizing hospitalization time and costs.18 Moreover, through multifactorial logistic regression analysis, the study shows that CT-PCI (OR=2.254) is an influencing factor for postoperative complications (Clavien-Dindo grade  $\geq$  II). This result further substantiates the previously mentioned connection between CT-PCI and postoperative complications. Elevated CT-PCI grading may signify a broader and more severe spread of the tumor within the abdominal and pelvic cavities, thereby increasing the postoperative complication risk.<sup>19</sup> Through multifactorial logistic regression analysis, the study found that a more precise evaluation of CT-PCI's impact on postoperative complications can be achieved by controlling other influencing factors. This refined assessment may guide clinicians in gauging the risk of complications in patients and in shaping treatment strategies. The ROC curve generated in this research indicates that the predictive AUC for CT-PCI concerning postoperative complications (Clavien-Dindo grade  $\geq$  II) is 0.854. This figure signifies that CT-PCI holds substantial accuracy in forecasting postoperative complications. This finding further endorses the credibility of CT-PCI as a determinant for predicting postoperative complications, suggesting that CT-PCI can distinguish, to a certain degree, between patients who are likely and unlikely to encounter postoperative complications.

The limitations of this study encompass the following factors: Firstly, as a retrospective analysis, the study inevitably bears the selection bias; Secondly, differences in CT machine manufacturers and variations in the number of spiral CT rows, along with diverse CT parameter configurations, may affect image quality and the ability to detect minor lesions; Thirdly, due to the difficulty in detecting lesions with a diameter smaller than 0.5 cm via CT, preoperative CT tends to underestimate the PCI score for patients with advanced rectal cancer compared to surgical assessment; Fourthly, the limited sample size in this study necessitates further validation through extensive sampling and multicenter research.

To summarize, preoperative CT-PCI can serve as an effective tool for gauging the short-term prognosis in patients undergoing radical rectal cancer surgery following neoadjuvant treatment. It offers valuable insights for clinical diagnosis and management, facilitating prompt intervention and enhancing patients' short-term prognosis.

#### ETHICAL COMPLIANCE

The ethics committee of Peking University International Hospital approved this study.

#### CONFLICT OF INTEREST

The authors have no potential conflicts of interest to report relevant to this article.

#### AUTHOR CONTRIBUTIONS

BZ, NZ, and YZ designed the study and performed the experiments; HG and WL collected the data, HG, WL and SL analyzed the data, BZ, NZ and YZ prepared the manuscript. All authors read and approved the final manuscript. BZ and NZ contributed equally to this work.

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