Body Fat Ratio as a Novel Predictor of Complications and Survival After Rectal Cancer Surgery

Haiyuan Zhao  
The First Affiliated Hospital of Wannan Medical College (Yijishan Hospital of Wannan Medical College

Gang Liu  
The First Affiliated Hospital of Wannan Medical College (Yijishan Hospital of Wannan Medical College

Yang Li  
The First Affiliated Hospital of Wannan Medical College (Yijishan Hospital of Wannan Medical College

Ben Liu  
The First Affiliated Hospital of Wannan Medical College (Yijishan Hospital of Wannan Medical College

Feixiang Lu  
The First Affiliated Hospital of Wannan Medical College (Yijishan Hospital of Wannan Medical College

Nianzhao Yang  
The First Affiliated Hospital of Wannan Medical College (Yijishan Hospital of Wannan Medical College

Jun Zhao  
dukzhao@163.com

The First Affiliated Hospital of Wannan Medical College (Yijishan Hospital of Wannan Medical College

Research Article

Keywords: Body fat ratio, postoperative rectal cancer, complications, survival, nomogram model

Posted Date: June 7th, 2024

DOI: https://doi.org/10.21203/rs.3.rs-4441516/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License

Additional Declarations: No competing interests reported.
Abstract

Aim

To investigate the relationship between body fat ratio (BFR), visceral fat area (VFA), body mass index (BMI), and visceral fat density (VFD) and to assess their reliability in predicting the risk of postoperative complications and survival status in patients with rectal cancer (RC).

Methods

The study prospectively included 460 patients who underwent surgical treatment for RC at the First Affiliated Hospital of Wannan Medical College between September 2018 and July 2021. BFR, VFA, BMI, and VFD were measured, and patients' basic information, clinical data, complications, and survival were recorded. Statistical analysis was performed to determine the optimal BFR cutoff and elucidate group differences.

Results

BFR exhibited significant correlations with VFA (R = 0.739), BMI (R = 0.783), and VFD (R = -0.773; all P < 0.05). The area under the receiver operating characteristic curve of BFR, VFA, BMI, and VFD in predicting postoperative complications were all > 0.7, with an optimal BFR cutoff value of 24.3. Patients in the BFR-low group had fewer postoperative complications and lower intraoperative indices, hospitalization times, and costs (P < 0.05) compared to the BFR-high group. BFR predicted complications with high diagnostic significance and was validated by multiple models. Patients in the BFR-high group had better survival than those in the BFR-low group (P < 0.05).

Conclusion

BFR is closely related to BMI, VFA, and VFD. Reasonable control of BFR or a modest increase may help prevent and treat postoperative complications of RC and improve patients’ long-term survival.

Introduction

The global incidence of colorectal cancer (CRC) is increasing annually. According to the latest statistics, CRC remains the third most common malignancy worldwide. In China, the incidence of CRC ranked fourth and fifth for women and men, respectively. In recent years, obesity has become a global public health concern. Visceral fat deposition can potentially affect surgical visibility, resulting in prolonged operation duration and increased intraoperative bleeding. In addition, it may contribute to a higher incidence of postoperative complications, impacting the postoperative survival status.
conventional body mass index (BMI), a commonly used indicator for assessing obesity, lacks accuracy in reflecting the accumulation and distribution of body fat. BMI provides a holistic representation of overall weight but lacks the ability to differentiate between muscle and fat proportions. This may result in substantial morphological differences among individuals with the same BMI, such as leaner athletes than the general population. Consequently, imaging-based evaluation methods, such as visceral fat area (VFA), have proven effective in prognostic evaluation for multiple tumors, including gastric cancer, liver cancer, and esophageal cancer. Nonetheless, the treatment of VFA necessitates the utilization of costly spiral computed tomography (CT) scanning equipment and specialized software. Moreover, subjective errors and measurement variability are present, rendering it impractical for conducting large-scale epidemiological investigations. By comparison, bioelectrical impedance analysis (BIA) provides a straightforward and cost-effective method for measuring body fat ratio (BFR) as it carries no radiation risks and is well-suited for large-scale implementation. Hence, there is a need for additional verification and investigation to determine the precise and reliable utility of BFR in assessing obesity and its potential role as a risk factor for postoperative complications in rectal cancer (RC). Furthermore, it is crucial to explore whether BFR has any effect on and can contribute to the improvement of long-term survival outcomes. Hence, this study explored the relationship between BFR, VFA, BMI, and VFD and to evaluate their reliability in assessing the risk of postoperative complications and survival status in patients with RC.

1 Materials and methods

1.1 Clinical data

Patients who underwent surgical treatment for RC between September 2018 and July 2021 in the First Affiliated Hospital of Wannan Medical College (Yijishan Hospital of Wannan Medical College) were prospectively recruited. The inclusion criteria were as follows: (1) RC diagnosed by imaging and pathological examination without distant metastasis, (2) absence of obvious contraindications to surgery and suitability for radical RC surgery, (3) absence of neoadjuvant chemoradiotherapy, and (4) complete clinical data and availability of postoperative long-term outpatient clinic and telephone follow-up information. The exclusion criteria were as follows: (1) non-RC or distant metastases confirmed by imaging and pathology; (2) poor general condition to the extent that they could not undergo surgical treatment or the absence of radical RC surgery, excluding colonic and ileal prophylactic stomas; (3) no abdominal computed tomography (CT) examination; (4) planned neoadjuvant radiochemotherapy in preoperative consultation with the physician-in-charge; and (5) incomplete BFR, BMI, VFD, and VFA values. Eventually, 460 patients were included in the analysis based on these criteria. BFR, BMI, visceral fat density (VFD), and VFA values as well as clinicopathologic data, postoperative complication status, surgery-related indexes, and postoperative recovery and long-term survival status of the patients were collected. The study protocol was approved by the Ethics Committee of the First Affiliated Hospital of Wannan Medical College (approval no.: 202220).

1.2 Methods
1.2.1 Research design

Data on patients’ BFR, BMI, VFD, and VFA values and postoperative complications were compiled using R software. Correlation analysis was performed, and visualization charts were generated. The accuracy of BFR, BMI, VFD, and VFA in predicting postoperative complications was assessed by receiver operating characteristic (ROC) analysis, followed by optimal cut-off value calculation for each indicator. Patients were divided into the BFR-high and BFR-low groups according to the BFR cut-off point value, and the differences in clinical data between the two groups were analyzed by statistical methods. The least absolute shrinkage and selection operator (LASSO) regression model was utilized to identify the relevant factors. Subsequently, a diagnostic nomogram was constructed by univariate and multivariate logistic analyses, and the model’s accuracy was validated. Finally, the survival status of patients in both groups was examined using the Kaplan–Meier survival curve (Fig. 1).

1.2.2 Measurement methods

Patients’ basic information was collected. Height and weight data were obtained using a SECA 213 height scale and a TANITA BC-601 body composition meter to calculate BMI (kg/m²). BFR values were measured using a TANITA BC-601 body composition meter (bioelectrical impedance analysis method) \(^{12}\).

For VFD measurement, postoperative pathology specimens were first extracted. Subsequently, volume and weight measurements were collected at three random locations (5 cm²) on the omentum majus using a volumetric cup: VFD value = weight (g)/volume (cm²). The average value was taken as the final VFD value.

VFA was measured by abdominal spiral CT scanning. In addition, abdominal CT images at the third lumbar level were captured using Slice-O-Matic software. Fat and muscle tissues were differentiated according to CT values (Hounsfield Unit, HU) to obtain VFA.

1.2.3 Preoperative preparation and surgical approach

All patients underwent preoperative examination, pre-perioperative evaluation, and symptomatic treatment. Conventional laparoscopic surgery was performed in the lying lithotomy position under general anesthesia. A lens was placed for abdominal exploration to detect tumor location, perirectal condition, and lymph node metastasis. The conventional laparotomy was performed through a lower abdominal incision, and lymph node dissection and digestive tract reconstruction were performed using a previously developed method\(^{13}\).

1.2.4 Postoperative complication

Spearman correlation analysis, ROC analysis, Kaplan–Meier survival analysis, and univariate and multivariate logistic analyses were
performed using statistical software R (4.2.1) and Bioconductor package. The diagnostic nomogram was constructed and visualized. Statistical analyses were performed using IBM SPSS Statistics 23.0 (IBM, Armonk, NY, USA), Excel 2016s and follow up visits.

Postoperative complications observed included incisional fat liquefaction, anastomotic fistula, postoperative bleeding, postoperative bowel obstruction, anastomotic stenosis, abdominal infection, respiratory infection, and postoperative voiding dysfunction. Survival status was routinely followed up every 3 months up to July 2023, with surgery time serving as the starting point.

1.2.5 Statistical analysis

9 (Microsoft Cooperation, USA), and GraphPad Prism 9.3 (GraphPad Software Inc, USA). Enumeration data were presented as the number of cases or percentage, and comparisons between groups were performed using the \( \chi^2 \) test or Fisher’s exact test. Measurement data were subjected to a normal distribution test. Measurement data conforming to normal distribution were expressed as mean ± standard deviation, and comparisons between groups were performed using the t-test. Comparisons between groups of the measurement data not conforming to normal distribution were performed using the Wilcoxon method. The Log-rank test method was employed for analyzing Kaplan-Meier survival curves. A P-value of <0.05 was considered statistically significant.

2 Results

2.1 Spearman correlation analysis among BFR, BMI, VFD, and VFA indicators

Significant positive correlations were observed between BFR and both BMI and VFA (correlation coefficients \( R = 0.783 \) and \( 0.739 \), respectively; both \( P < 0.001 \)). In addition, BFR exhibited a significant negative correlation with VFD (\( R = -0.773, P < 0.001 \)). The correlations between BFR, BMI, VFD, and VFA were statistically significant (Fig. 2).

2.2 Postoperative complications

The overall incidence of postoperative complications was significantly higher in the BFR-high group than that in the BFR low group. Specifically, the incidence of incisional fat liquefaction, postoperative bleeding, anastomotic fistula, and chylous leakage was significantly different between the two groups (\( P < 0.05 \)). However, the Clavien–Dindo grade did not exhibit a statistically significant difference between both groups (Supplementary Table 1). Therefore, the postoperative complication severity between both groups was similar, with no significant difference (\( P > 0.05 \)) (Table 1).

2.3 Accuracy of BFR, BMI, VFD, and VFA indicators in predicting patients’ risk of complications

Diagnostic ROC curves were plotted using the BFR, BMI, VFD, and VFA indicators, which also predicted postoperative complications in RC. All four indicators were valuable in predicting postoperative complications of RC, with area under the ROC curve (AUC) values of 0.891, 0.810, 0.810, and 0.797,
respectively (Fig. 3). The optimal cut-off values for BFR, BMI, VFD, and VFA in predicting postoperative complications in RC were determined based on ROC curve analysis as 24.3, 25.82, 0.706, and 110.5, respectively (Supplementary Table 2).

2.4 Comparison of clinical baseline data and pathologic findings between both BFR groups

A total of 460 patients were subjected to the final cohort analysis. The patients were categorized into the BFR-low and BFR-high groups based on the optimal BFR cutoff value (24.3). No significant differences were observed between both groups in terms of sex, age, smoking history, Eastern Cooperative Oncology Group scale, and comorbidities (including pulmonary diseases, hypertension, diabetes mellitus, others, and multiple comorbidities) (P > 0.05). However, in the specific categorization of comorbidities, the comparison of cardiovascular diseases produced a significant difference (P < 0.05). Furthermore, both groups were also compared in terms of preoperative, intraoperative, and postoperative conditions. No significant differences were observed between them in terms of preoperative hemoglobin, carcinoembryonic antigen, and albumin (P > 0.05). Patients in the BFR-high group had significantly prolonged operation duration, more intraoperative bleeding, longer hospitalization time, higher hospitalization costs, and later onset of the first anal exsufflation and abdominal drainage tube extubation (all P < 0.05). However, no significant differences were observed between both groups in terms of surgical approach, ASA grading, time to first defecation, time to first fluid intake, and time to catheter extubation (P > 0.05). In terms of postoperative pathologic findings, the number of lymph node dissections was significantly lower in the BFR-high group than that in the BFR-low group (P < 0.05). However, no significant differences were observed in tumor-node-metastases stage, degree of differentiation, nerve invasion, vascular cancer embolus, number of positive lymph nodes, and distance of the tumor from the anal verge between both groups (P > 0.05) (Supplementary Table 3).

2.5 Construction of multiple diagnostic prediction models for diagnosing postoperative complications in RC

Seven variables with non-zero coefficients (BFR, VFA, VFD, age, multiple comorbidities, number of lymph node dissection, and number of positive lymph nodes) were screened using a LASSO regression model (Figs. 4A and 4B; Supplementary Table 4). The nomogram demonstrated the effect of each predictor on risk events for comorbidities, which were visualized and transformed into patient prognostic probabilities. A concordance index (C-index) of 0.916 (95% confidence interval: 0.882–0.950) was recorded, suggesting high discrimination of the model (Fig. 4C). The high accuracy of the nomogram was validated by diagnostic calibration graphs, ROC curves, and decision curve analysis (DCA) curves (Figs. 4D–4F). Subsequently, these seven variables were subjected to univariate and multivariate logistic analyses. BFR, VFD, age, and number of positive lymph nodes were identified as risk factors for the development of complications (P < 0.05) (Supplementary Table 5).

2.6 Postoperative survival
Data from patients with follow-up times less than 3 years were excluded. The 3-year survival rates of patients in the BFR-high and BFR-low groups were 86.2% and 72.4%, respectively. Overall, the survival rate in the BFR-high group was significantly higher than that in the BFR-low group (P < 0.05) (Fig. 5).

3 Discussion

Obesity stands as a significant risk factor for various chronic diseases, with a particular emphasis on its association with digestive system tumors, notably colorectal cancer (RC), which boasts both a high incidence and a challenging prognosis. It is, therefore, of paramount importance to maintain a high level of vigilance against obesity in order to mitigate the attendant risk. Obesity in patients with RC can increase the risk of numerous metabolic disorders, including but not limited to hypertension, cardiovascular and cerebrovascular diseases, and diabetes. Furthermore, obesity compounds the risk factors associated with RC. Therefore, identification of the potential prognostic markers and new therapeutic targets for obese patients with RC is necessary. Despite advancements in treatment, postoperative complications and tumor recurrences continue to severely affect patient survival and prognosis. In particular, complications may lead to difficulties in subsequent treatment, further jeopardizing patients’ survival prospects. Therefore, improving the surgical outcome and prognosis of patients with RC has become an important topic of current research.

As two indicators of fat distribution that have received much attention, VFA and BMI are closely associated with the incidence and prognosis of RC. However, these metrics suffer some limitations. VFA utilizes X-rays as a source of radiation to differentiate between fat, non-fat, and bone mineral mass by measuring the attenuation of X-rays in different tissues of the body. Due to the high level of radioactivity, expensive equipment, the need for appropriate software systems, and subjective judgment of the results, VFA has low safety, low cost-effectiveness, and high errors. While BMI serves as a commonly used and straightforward measure of body mass, and is positively correlated with BFR, BMI cannot distinguish between fat and muscle mass and may misclassify individuals with greater muscle mass as obese. Therefore, they do not accurately reflect patient body mass and the specific impact on RC treatment.

BFR more accurately reflects the actual degree of obesity in an individual compared to BMI. BFR also accurately characterize adipose tissue distribution and abnormal proportions. In addition, it is associated with metabolic disorders and is more sensitive to changes in the intra-abdominal environment. However, studies on BFR in the preoperative assessment of body mass and its effect on RC surgery are scarce. To our knowledge, the present study is the first to propose the concept of VFD, and the accuracy of BFR was validated by pathology. Some large and fragile fat particles were observed in obese patients. This phenomenon makes surgical maneuvers more prone to bleeding and incorrect entry to inappropriate anatomical levels, thus increasing the risk of complications. Therefore, in this study, the correlation between BFR and VFA, BMI, and VFD indexes was thoroughly investigated and
validated. In addition, the relationship between BFR values and postoperative complications and prognosis of RC was explored.

Our findings showed that BFR exhibited a significant positive correlation with VFA and BMI but a significant negative correlation with VFD. These metrics accurately reflect the degree of obesity in patients and predict postoperative complications in RC. This is consistent with previous findings that VFA and BMI are associated with intraoperative and postoperative complications and poor prognosis in patients with RC, further validating the importance of BFR and VFD\textsuperscript{20,21}. However, the optimal diagnostic cut-off points for these metrics are different. Therefore, further optimization of selecting metrics for predicting complications at specific levels of obesity is needed. To minimize statistical errors, the optimal cut-off values obtained should be used to classify patients into the BFR-high and BFR-low groups, rather than relying solely on the standardized or median values of BFR. To mitigate potential errors introduced by grouping, we opted to use cutoff values of body fat percentage to delineate high and low groups. Given the variation in normal ranges of body fat percentage across different genders and age groups, categorizing into high, normal range, and low groups, or tripartitioning from high to low values, would result in increased rates of true positives and false positives. Multivariate logistic analysis identified BFR, VFD, age, and number of positive lymph nodes as factors associated with the risk of complications.

The nomogram visualized the impact of each predictor on the risk event of complications and translated it into patient prognostic probabilities. According to nomogram observations, the BFR value had a relatively high scale on the graph, indicating a certain role of BFR in determining the risk of complication. In addition, the model exhibited high accuracy and reliability with a corresponding C-index value of 0.916 (95% CI: 0.882–0.950). Seven variables were identified among those with non-zero coefficients in the LASSO regression model, including BFR, VFA, VFD, age, multiple comorbidities, number of lymph node dissection, and number of positive lymph nodes. These variables exerted a significant impact on predicting postoperative complications in RC. These findings suggest a certain potential application and clinical significance of the model in predicting the risk of complications.

Patients in the BFR-high group had prolonged operation duration, more intraoperative bleeding, and a higher incidence of intraoperative complications during radical RC surgery compared with those in the BFR-low group. Surgeons often encounter technical surgical limitations during RC surgery in obese patients, including poor surgical visualization and operative difficulties, especially in men with low RC. These unfavorable factors increase the difficulty of surgical dissection, prolong the time of radical RC surgery, and increase the risk of bleeding and complications. In addition, lymph node metastasis is a key factor affecting the prognosis of patients with RC. In radical RC surgery, lymph node dissection is crucial for surgical treatment and subsequent efficacy, serving as a key index for evaluating RC surgery. Patients in the BFR-high group may have a reduced number of lymph nodes dissected. However, BMI is not responsible for influencing intraoperative lymph node dissection\textsuperscript{22}. High BFR in patients may increase the difficulty of intraoperative lymph node dissection and decrease the effectiveness of dissection, thereby affecting the efficacy of RC surgery. In summary, BFR exerts an important effect on the outcome
of RC surgery; high BFR values increase the difficulty of surgery and the risk of intraoperative complications. In addition, higher BFR may affect the effect of peristomal lymph node dissection, thereby affecting the efficacy of RC surgery. Therefore, for obese patients, especially those with high BFR, enhanced operating skills are needed in RC surgery to improve surgical outcomes.

VFA and BMI are critical in reducing the risk of surgical complications and improving the quality of life (QoL) and survival in patients with RC. Patients in the BFR-high group had an increased risk of RC surgical complications, which adversely affected postoperative recovery. These patients exhibited significantly prolonged hospitalization time, increased operation duration, increased intraoperative bleeding, prolonged anal ventilation, delayed dietary recovery, increased hospitalization costs, and decreased number of lymph node dissection (P < 0.05). To reduce the risk of these complications, especially in RC patients with comorbid metabolic syndrome, preoperative measures should be taken to reduce the BFR. According to Matsui et al., adiponectin, an adipokine with protective effects, may lead to surgical complications, including surgical site infection and pneumonia. Hypertension and dyslipidemia are associated with impaired microvascular circulation, which may lead to poor tissue healing and increased risk of wound complications and anastomotic leakage. Although each factor exerts a small effect on postoperative outcomes, the risk of postoperative complications is significantly increased when multiple factors are present concurrently. Future studies should focus on the association between BFR and postoperative inflammatory markers, thus validating its significance in RC surgery.

Low BFR may lead to poor prognosis in patients with RC. This may be attributed to the patient's nutritional status, as reflected by the BFR. Good nutritional status helps to combat unfavorable risks and promotes long-term survival. Hence, malnourished patients tend to have a poorer prognosis. Caution is, therefore, needed when considering interventions to reduce VFA. Visceral fat may regulate tumor cell behaviors such as growth, adhesion, and invasion by influencing adipocytokines. Low adiponectin levels are associated with the development of malignant tumors and poor prognosis, as adiponectin plays an anticancer role in inhibiting tumor cell proliferation and promoting apoptosis. However, whether high BFR effects patient prognosis solely through postoperative complications remains controversial, which is a limitation of this study. In addition, the sample size of this single-center study was small, thus warranting future multicenter, large-sample studies. In RC patients, BFR is positively correlated with VFA and BMI, while negatively correlated with VFD. However, this study did not explore the correlation among these four factors in healthy individuals, which is a limitation. To enhance the completeness and accuracy of our research, we will conduct further experiments to comprehensively observe the correlation among these four factors in the healthy population. Moreover, the current research on the relationship between BFR and tumors remained at the level of clinical research. The underlying mechanism, especially its association with related indicators reflecting obesity in vivo (e.g., lipids, serum leptin, adiponectin, and their receptors), has not yet been fully explored. Therefore, these aspects need to be further explored to deepen the understanding of BFR involvement in the prognosis of patients with RC.
4 Conclusion

Accurate assessment of BFR, VFA, VFD, and BMI can clarify the degree of obesity and fat distribution in patients with RC. The selection of appropriate surgical plans and postoperative management strategies provides new ideas and reliable support for the development of personalized treatment strategies, thereby improving patients’ QoL and extending their survival duration.

Declarations

Funding:
The present study was supported by the Natural Science Foundation of Anhui Province (grant no. 1808085MH271) and the Special Fund for Wannan Medical College Scholar Project (grant no. WK2021F07 and WK2021F17).

Conflicts of interest/Competing interests:
The authors declare no competing interests.

Data availability:
The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Code availability:
Not applicable.

Authors' contributions:

- Haiyuan Zhao: Study concepts, Study design, Data acquisition, Quality control of data and algorithms, Data analysis and interpretation, Statistical analysis, Manuscript preparation, and Manuscript editing & review.
- Gang Liu: Data acquisition, Data analysis and interpretation, and Statistical analysis.
- Yang Li: Data acquisition, Quality control of data and algorithms, Manuscript preparation, and Manuscript editing.
- Ben Liu: Data acquisition, Quality control of data and algorithms, and Data analysis and interpretation.
- Feixiang Lu: Statistical analysis, Manuscript preparation, and Manuscript editing.
- Jun Zhao: Study concepts, Study design, and Manuscript editing & review.

Ethics approval and consent to participate:
The Ethics Committee of The First Affiliated Hospital of Wannan Medical College (Yijishan Hospital) approved the present study (approval no. 202220).
Patient consent for publication:
All patients participating in the study signed informed consent prior to participation.

Statement

All experimental methods were carried out in accordance with relevant guidelines and regulations. All procedures involving human or animal subjects in this study were approved by the Institutional Ethics Committee and conducted in strict adherence to internationally recognized ethical standards and research practices.

Acknowledgments

We thank Bullet Edits Limited for the linguistic editing and proofreading of the manuscript.

References


### Tables

**Table 1: Postoperative complications**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>BFR-low</th>
<th>BFR-high</th>
<th>( \chi^2 )</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 324</td>
<td>n = 136</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anastomotic fistula, n (%)</td>
<td>7 (2.2%)</td>
<td>9 (6.6%)</td>
<td>4.42</td>
<td>0.04</td>
</tr>
<tr>
<td>Postoperative bleeding, n (%)</td>
<td>7 (2.2%)</td>
<td>5 (3.7%)</td>
<td>0.37</td>
<td>0.54</td>
</tr>
<tr>
<td>Bowel obstruction after abdominal surgery, n (%)</td>
<td>9 (2.8%)</td>
<td>4 (2.9%)</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Anastomotic stenosis, n (%)</td>
<td>3 (0.9%)</td>
<td>1 (0.7%)</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Abdominal infection, n (%)</td>
<td>7 (2.2%)</td>
<td>9 (6.6%)</td>
<td>4.42</td>
<td>0.04</td>
</tr>
<tr>
<td>Infection of the incisional wound, n (%)</td>
<td>10 (3.1%)</td>
<td>16 (11.8%)</td>
<td>13.53</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pulmonary infection, n (%)</td>
<td>3 (0.9%)</td>
<td>4 (2.9%)</td>
<td>1.43</td>
<td>0.23</td>
</tr>
<tr>
<td>Postoperative voiding dysfunction, n (%)</td>
<td>8 (2.5%)</td>
<td>2 (1.5%)</td>
<td>0.10</td>
<td>0.75</td>
</tr>
<tr>
<td>Total incidence of complications, n (%)</td>
<td>54 (16.6%)</td>
<td>50 (36.7%)</td>
<td>22.11</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Abbreviation: BFR, body fat ratio.

### Figures
Figure 1

Research flowchart. Abbreviations: RC, rectal cancer; ROC, receiver operating characteristic; BFR, body fat ratio; LASSO, least absolute shrinkage and selection operator.
Figure 2

Correlation analysis among BFR, BMI, VFD, and VFA indicators. (A–C): Scatter plot of correlation among BFR and BMI, VFD, and VFA. (D): Heat map of correlation among BFR and BMI, VFD, and VFA. Abbreviations: BFR, body fat ratio; BMI, body mass index; VFD, visceral fat density; VFA, visceral fat area.
**Figure 3**

**ROC curves for predicting postoperative complications in RC.** The AUC values for BFR, BMI, VFD, and VFA are 0.891, 0.810, 0.810, and 0.797, respectively. Abbreviations: ROC, receiver operating characteristic; RC, rectal cancer. AUC, area under the curve.
Figure 4

Risk factors for postoperative complications in patients with RC predicted by the nomogram model and LASSO regression analysis. (A). Utilizing the binomial deviation of the regularization parameter \( \lambda \) as a tuning criterion, lambda.min was selected. Through 10-fold cross-validation, a corresponding count of non-zero coefficients was determined, amounting to 7. (B). The dynamic process of Lasso regression involves the filtration of coefficients for key factors. (C). The construction of the nomogram, encompassing all significant predictors of postoperative complications, is comprehensive. Predictive
factors include BFR, VFA, VFD, age, multiple comorbidities, lymph node dissection count, and positive lymph node count. The cumulative sum of acceptance points for each variable is plotted on the total point axis. A line is drawn downward to the prediction axis, effectively determining the probability of the predicted outcome. (D). The calibration curve of the nomogram, predicting postoperative complication rates, plots actual occurrence probabilities on the y-axis and nomogram-predicted probabilities on the x-axis. Calibration is assessed using the Hosmer-Lemeshow Goodness of Fit method, revealing no significant disparities between predicted and observed values. This indicates a well-fitted model.

(E). Validation of the nomogram's accuracy is achieved through the ROC curve, yielding an AUC value of 0.916, signifying a high level of precision. (F). Clinical decision curve analysis demonstrates that the riskscore curve consistently outperforms the All and None reference lines across a substantial probability threshold range. This indicates superior model performance. Abbreviations: RC, rectal cancer; LASSO, least absolute shrinkage and selection operator.

Figure 5
Survival curves of patients in the BFR-high and BFR-low groups. Survival analysis conducted on patients with RC using the Kaplan-Meier plotter online database revealed that the overall survival of BFR-High patients (yellow line, n=136) was significantly lower than that of BFR-Low patients (blue line, n=324). Excluded data points represent patients who remained alive until the end of follow-up, those who did not attend follow-up appointments, and those who succumbed to other causes before the conclusion of the follow-up period. Abbreviation: BFR, body fat ratio. RC, rectal cancer

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementarydata.docx