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Assessment of Preoperative Geriatric Nutritional Risk Index and Monocyte Count in Predicting Acute Postoperative Pain of Colorectal Cancer Patients after Laparoscopic Surgery

Ying Zhang
zhejiang cancer hospital
Ze Chai
zhejiang cancer hospital
Ziyan Weng
zhejiang cancer hospital
Xiaoying Wang
zhejiang cancer hospital
Junbo Yuan
zhejiang cancer hospital
Yun Cheng
zhejiang cancer hospital
Shunv Cai
caisn@zjcc.org.cn

Wenzhou Medical University

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Abstract

Background

Preoperative nutritional and inflammatory status significantly influences surgical recovery, yet its relationship with postoperative pain remains underexplored. This study investigates preoperative nutrition and inflammation in patients undergoing laparoscopic colorectal surgery to develop a personalized approach for predicting postoperative pain.

Methods

A total of 586 colorectal cancer patients who underwent laparoscopic surgery, from October 2024 to June 2025, were recruited in our study. Patients were stratified into severe and mild postoperative pain groups using a numerical rating scale (NRS) cutoff of 3. All the nutritional and inflammatory data (geriatric nutritional risk index [GNRI], nutrition risk screening 2002 [NRS2002], body mass index [BMI], C-reactive protein, monocyte count, etc.) were collected before surgery. All patients were administered with preoperative transversus abdominis plane (TAP) block and postoperative patient-controlled analgesia (PCA). Differences between groups were analyzed using univariable and multivariable logistic regression, subgroup analysis, and negative binomial regression.

Results

Multivariable analysis revealed that geriatric nutritional risk index (OR = 0.50, $p < 0.001$) and monocyte count (OR = 0.05, $p = 0.005$) were independent protective factors against postoperative pain, whereas patient-controlled analgesia press count (OR = 3.02, $p < 0.001$) was an independent risk factor. The protective effects of both were attenuated in patients receiving preoperative ropivacaine nerve block compared with liposomes.

Conclusions

Preoperative Geriatric Nutritional Risk Index and monocyte count are novel predictors of inadequate analgesia after laparoscopic colorectal cancer surgery. Transversus abdominis plane block combined with patient-controlled analgesia significantly improves postoperative comfort and recovery.

1. Introduction

Colorectal cancer (CRC) ranks among the most harmful malignant neoplasms of the digestive tract, characterized by asymptomatic early stages that substantially impair patients' quality of life[2,3]. In recent years, with the increasing use of laparoscopic-assisted radical resection for CRC, significant benefits have been observed in relieving surgical trauma, accelerating early postoperative recovery of body

function, and reducing related complications. However, despite advances in multimodal analgesia and enhanced recovery after surgery (ERAS) protocols, postoperative pain remains a major concern for patients undergoing laparoscopic surgery and is a key factor affecting postoperative recovery[4–6].

Preoperative physiological status has been shown to significantly influence postoperative outcomes[7,8], and nutritional status and inflammatory indicators have gained considerable attention in recent years. Weak preoperative nutrition is insidious and often overlooked, as it is difficult to detect, but it frequently occurs in clinical practice and may lead to severe postoperative complications such as infection, poor wound healing, and increased mortality[9,10].

Mini nutritional assessment tools, such as the prognostic nutritional index (PNI), nutrition risk screening 2002 (NRS2002), and geriatric nutritional risk index (GNRI), have shown promise as prognostic indicators for various diseases. In particular, the PNI, which is calculated using serum albumin levels and total lymphocyte count in peripheral blood, was originally proposed to assess perioperative immune nutritional status and surgical risk for patients undergoing gastrointestinal surgery. PNI has been shown to be a prognostic marker for various malignancies[11–14]. Meanwhile, geriatric nutritional risk index (GNRI) is a nutritional screening and assessment tool that can predict nutrition-related complications in patients[15]. A lower value of GNRI indicates a higher nutrition-related risk. In a previous study of elderly patients with acute heart failure, it was found that a GNRI < 92 is associated with poor clinical outcomes[16]. In another 3-year follow-up study, a GNRI < 92 was reported to be associated with higher mortality and suggested as a useful clinical trigger for routine nutritional treatment[17]. However, only a few articles use GNRI to predict postoperative pain outcomes, and its cut-off value remains unclear. Unlike PNI, GNRI does not rely on lymphocyte count which can be confounded by acute inflammation, and thus may better reflect chronic nutritional status in cancer patients.

Meanwhile, C-reactive protein (CRP) and circulating leukocytes are markers that reflect the body's inflammation status. An article in a high-impact journal mentioned that peripheral and central nervous system pathways are sensitized by pro-inflammatory factors and activated immune cells, lowering pain thresholds and amplifying pain perception[18]. Giordano et al. and colleagues also quantified that, for patients undergoing total knee arthroplasty, deep phenotyping of inflammatory mediators, such as CD244 and STAMPB, was different in 12-month postoperative pain intensities and function scores[19]. Therefore, malnutrition, along with inflammation markers, may aggravate biological susceptibility to pain.

The relationship among preoperative nutrition, inflammatory indicators, and postoperative pain has rarely been studied. The signaling pathway of pain remains ambiguous. However, CRC patients often suffer from severe nutritional and inflammatory stress, typically resulting from reduced food intake and metabolic abnormalities, characterized by a negative balance between protein metabolism and energy[7]. Thus, further research is required to improve postoperative pain management methods. Therefore, the present study was designed to clarify the clinical impact of preoperative nutrition and inflammatory

markers, which may guide postoperative pain management in patients undergoing laparoscopic surgery (Fig. 1).

2. MATERIALS AND METHODS

2.1 Study Design and Data Sources

Institutional Review Board approval for this retrospective cohort study was granted by the Ethics Committee of Zhejiang Cancer Hospital (IRB-2025-1569 (IIT)). The requirement for informed consent from participants was waived in accordance with IRB regulations.

A total of 586 colorectal cancer patients who underwent laparoscopic surgery from October, 2024 to and June, 2025 were retrospectively enrolled. Inclusion criteria were receiving general anesthesia, postoperative patient-controlled analgesia for 24h and underwent laparoscopic surgery or stoma reversal surgery. Exclusion criteria:1) Those with advanced rectal cancer, severe liver and kidney dysfunction, and intestinal inflammation; 2) emergency surgery, conversion to laparotomy, and inability to establish pneumoperitoneum during surgery; 3) patients with blurred consciousness, cognitive and communication barriers, mental illness; and 4) female patients during pregnancy and childbirth (Fig. 2).

Demographic data (gender, age, height, weight, etc.), preoperative data (serum albumin, cholesterol, etc.), and process data (surgical methods, nerve block, intraoperative medication, postoperative analgesia medication, etc.) were collected. The data presented in the current study were extracted from the patients' electronic medical records. Outcome data (pain intensities during movement, cumulative analgesic consumption, side effects of analgesics, etc.) were collected by an acute pain service group at different time points postoperatively[20–22]. Among the enrolled patients, approximately 84.5% of the patients underwent laparoscopic surgery while others underwent Stoma Reversal Surgery. All data were assessed and edited by two authors (ZY, CY). If missing data or extreme values occurred, the relevant raw data were double-checked. Participants' names or other forms of identification were deleted before analysis. The reporting of this study followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) [23] and RECORD (Reporting of Studies Conducted Using Observational Routinely Collected Health Data) [24] guidelines.

2.2 Exposure Assessment

Preoperative nutritional and inflammatory markers were collected from fasting blood samples drawn within 7 days before surgery: BMI, NRS-2002 score, GNRI, prealbumin, albumin, globulin ratio, C-reactive protein, lymphocyte count, neutrophil count, monocyte count, PNI, CALLY, and NPS. All blood samples were detected by Sysmex XE-2100 automatic hematology analyzer (Sysmex Corporation, Kobe, Japan) for routine blood indexes including leukocyte count, lymphocyte count, neutrophil count and monocyte count; biochemical indexes such as prealbumin, albumin, globulin and C-reactive protein (CRP) were measured by Hitachi 7600 automatic biochemical analyzer (Hitachi High-Technologies Corporation,

Tokyo, Japan). Body mass index (BMI) was calculated as weight (kg) / height²(m²). The GNRI was calculated based on the patient's weight, height and serum albumin as follows: GNRI = [1.489 × albumin (g/L)] + [41.7 ×(weight/WLo)]. The WLo is the ideal weight and was calculated using the Lorentz formula as WLo = 0.75 × height (cm) − 62.5 for men and WLo = 0.60 × height (cm) − 40 for women[1]. When weight exceeded ideal weight, the ratio of weight/WLo was set to 1. Similar to previous studies, the GNRI of92 was taken as an original cut-off value[25–27]. PNI was calculated as: 10 × serum albumin (g/dL) + 0.005 × total lymphocyte count. CALLY was derived using the formula: albumin (g/L) × lymphocyte count (10^9/L) / [CRP (mg/L) × 10]. NPS was calculated by summing the scores of its four key components: neutrophil–lymphocyte ratio (NLR), platelet–lymphocyte ratio (PLR), albumin, and cholesterol.

Postoperative pain outcomes included the number of PCA requests, incidence of adverse reactions, and use of postoperative pain injections. There were no significant differences in the aforementioned variables, except for sex ($p = 0.018$), monocyte count ($p = 0.009$), and PCA requests ($p < 0.001$) (Table 1).

Table 1
Demographic, preoperative variables, postoperative pain score and surgical methods.

Characteristic	Total	weak postoperative pain	Strong postoperative pain	P value
Gender	586 (100%)	332 (100%)	254 (100%)	0.018
Male	221 (37.7%)	111 (33.4%)	110 (43.3%)	
Female	365 (62.3%)	221 (66.6%)	144 (56.7%)	
Age; year	65.00 (57.00–72.00)	65.00 (58.00-71.25)	65.00 (55.00–72.00)	0.111
Height (cm)	165.00 (158.00-170.00)	165.00 (159.75–170.00)	163.00 (157.00-170.00)	0.229
Weight (kg)	61.00 (54.00-68.38)	61.00 (55.00–70.00)	60.00 (54.00–67.00)	0.150
NRS2002	586 (100%)	332 (100%)	254 (100%)	0.216
NRS2002 ≥ 3	204 (34.8%)	108 (32.5%)	96 (37.8%)	
NRS2002 < 3	382 (65.2%)	224 (67.5%)	158 (62.2%)	
GNRI	107.87 ± 9.17	108.29 ± 9.45	107.32 ± 8.79	0.094
BMI; kg m − 2	23.05 ± 3.03	23.17 ± 3.15	22.89 ± 2.86	0.228
Cholesterol (mmol/L)	4.69 ± 0.96	4.66 ± 0.97	4.73 ± 0.93	0.343
Prealbumin (g/L)	240.41 ± 80.77	243.61 ± 81.16	236.23 ± 80.23	0.273
Albumin (g/L)	43.47 ± 4.44	43.61 ± 4.37	43.30 ± 4.53	0.100
albumin/globulin ratio	1.61 ± 0.28	1.61 ± 0.28	1.61 ± 0.27	0.921
C-Reactive Protein (mg/L)	6.84 ± 15.25	6.77 ± 15.47	6.92 ± 14.99	0.154
Lymphocyte Count (10^9/L)	1.47 ± 0.59	1.49 ± 0.61	1.43 ± 0.56	0.317
Neutrophil Count (10^9/L)	3.95 ± 1.82	3.91 ± 1.58	4.02 ± 2.09	0.983
Monocyte Count (10^9/L)	0.50 ± 0.41	0.55 ± 0.47	0.43 ± 0.31	0.009
CALLY	5.63 ± 11.73	6.66 ± 14.48	4.29 ± 6.37	0.132
PNI	50.80 ± 5.54	51.05 ± 5.64	50.47 ± 5.40	0.080
NPS	586 (100%)	332 (100%)	254 (100%)	0.107
NPS ≥ 3	145 (24.7%)	91 (27.4%)	54 (21.3%)	
NPS < 3	441 (75.3%)	241 (72.6%)	200 (78.7%)	

Characteristic	Total	weak postoperative pain	Strong postoperative pain	P value
Preoperative nerve block medication	586 (100%)	332 (100%)	254 (100%)	0.118
Liposome	295 (50.3%)	177 (53.3%)	118 (46.5%)	
Ropivacaine	291 (49.7%)	155 (46.7%)	136 (53.5%)	
PCA; count	1.68 ± 2.92	1.04 ± 1.61	2.53 ± 3.87	< 0.001
Surgical Method	586 (100%)	332 (100%)	254 (100%)	0.498
laparoscopic surgery	495 (84.5%)	277 (83.4%)	218 (85.8%)	
Stoma Reversal Surgery	91 (15.5%)	55 (16.6%)	36 (14.2%)	
Side effects of PCIA				
Hypotension	21 (3.6%)	12 (3.6%)	9 (3.5%)	1.00
Nausea/Vomiting	30 (5.1%)	12 (3.6%)	18 (7.1%)	0.089
Pruritus	1 (0.2%)	1 (0.3%)	0 (0.0%)	1.00
Dizziness	19 (3.2%)	8 (2.4%)	11 (4.3%)	0.286
Somnolence	2 (0.3%)	1 (0.3%)	1 (0.4%)	1.00

2.3 Anesthetic and Analgesic Protocol

Within one hour before surgery, all patients received the transversus abdominis plane (TAP) block, a therapeutic adjunct for analgesia after abdominal surgeries, which plays a valuable role in multimodal analgesia. The medicine used for TAP was ropivacaine 75 mg diluted with 40 mL of saline solution or liposomal bupivacaine (Exparel®) diluted with 40 mL of saline solution. The operation time and the medicine used for TAP will be registered by our preoperative staff.

All patients were treated according to the standard procedures at Zhejiang Cancer Hospital. General induction was performed in accordance with the regimen used in our center, which included 0.3 mg.kg-1 midazolam, 0.25 mg.kg-1 oxycodone, 1.5–2 mg.kg-1 propofol, and 0.9 mg.kg-1 rocuronium. Total intravenous anesthesia with propofol and remifentanil was used for anesthesia maintenance. The patients were transferred to the postoperative care unit for at least 1 h for recovery and were then returned to the ward after surgery.

Postoperative patients received patient-controlled intravenous analgesia (PCA) therapy. The postoperative analgesia regimen consisted of 3.5 μg/kg sufentanil diluted to 0.8 mg/mL with normal saline, 6–8 mL per bolus with no background, a lock-out time of 10 min, and a limited dosage of 12–16 mg per hour, depending on the weight and baseline status of the patient. When experiencing pain,

patients could press the button to self-administer analgesia. The nursing staff recorded the number of PCA requests and the activity-related NRS pain score within 24 hours after surgery. Other pain management regimens, such as acetaminophen 500 mg, ibuprofen 400 mg, and tramadol 100 mg, were given as needed for the patient reported insufficient pain. Intramuscular morphine was administered for breakthrough pain. If the above methods didn't provide significant benefits, the patient's postoperative intolerable pain can also be alleviated by adjusting the infusion dose of the analgesic pump.

2.3.4 Observation indicators

The primary outcome was inadequate postoperative analgesia, defined as a Numerical Rating Scale (NRS) score during movement (e.g., coughing, turning) at 24 hours postoperatively. NRS ranges from 0 (no pain) to 10 (worst imaginable pain). Based on prior studies[28,29], the optimal cut-off point of NRS for cancer is 3.5 with the sensitivity (88.5%), specificity (80.6%) and an AUC of 0.904. Thus, we used the dividing line between the two groups is NRS ≥ 3, which not only can define a strong postoperative pain due to inadequate analgesia but also exhibits high sensitivity and specificity.

Secondary outcomes included:1. Total number of PCA button presses within 24 hours (recorded electronically by the infusion pump); 2. Incidence of opioid-related adverse events (nausea, vomiting) within 3 days after surgery. 3. Frequency of postoperative pain injection administration within the 3 days postoperative period, documenting whether the patient required additional painkillers following surgery.

3. Statistical analysis

The statistical evaluation was performed using R (Version 4.5.2; R Core Team 2025) and IBM SPSS Statistics software (IBM SPSS Statistics for Windows, Version 31, Chicago, IL). Continuous variables are presented as mean ± standard deviation (SD) or median with interquartile range (IQR), depending on their distribution. The independent samples t-test or Mann-Whitney U test was applied for comparisons between groups, as appropriate.

Receiver operating characteristic (ROC) analysis was performed for each parameter, and to obtain the optimal cut-off value, the Youden index was calculated. The Youden index is a function of sensitivity and specificity and is a commonly used measure of overall diagnostic effectiveness in combination with ROC analysis. It detects the maximum vertical distance or difference between the ROC curve and the diagonal (chance) line, occurring at the cut-point that optimizes the biomarker's differentiating ability when equal weight is given to sensitivity and specificity. Variables with AUC < 0.60 in ROC analysis were retained as continuous variables to avoid information loss. Area under the ROC curve, sensitivity, specificity, positive predictive value, negative predictive value, and accuracy were obtained. However, the area under the ROC curve (AUC) for monocyte count is low, indicating the limited discriminative ability of the model. We treated it as a continuous variable to reduce bias.

Univariable analysis was used to filter statistically significant differences between groups. Multivariable logistic regression analysis was performed to estimate predictors of postoperative pain, including all

significant factors from the univariable analysis. The significance level was set at $p < 0.05$.

4. Results

4.1 Study cohort

Demographic and preoperative laboratory data are summarized in Table 1. Patients with strong postoperative pain (NRS ≥ 3) had significantly lower monocyte counts (0.43 vs. 0.55 $\times 10^9$/L, p = 0.009) and higher PCA demand (2.53 vs. 1.04 presses, p < 0.001) compared to those with mild pain. There were more female than male included in the weak pain group and the proportion of men increased in the severe pain group (p = 0.018).

Table 1. is presented on the final page of this manuscript

4.2Preoperative nutritional indicators have a correlation with the postoperative pain.

First, ROC curve analysis was performed to determine the area under the curve and the optimal cutoff value for each parameter. An univariable logistic regression analysis was conducted to identify potential predictors for pain on movement within the 24-hour postoperative period. As shown in Fig. 2, the results demonstrated that GNRI (OR = 0.44, 95% CI: 0.31–0.62, p < 0.001), BMI (OR = 0.69, 95% CI: 0.49–0.97, p = 0.032), albumin (OR = 0.64, 95% CI: 0.45–0.90, p = 0.010), monocyte count (OR = 0.44, 95% CI: 0.27–0.7, P < 0.001), and PNI (OR = 0.54, 95% CI: 0.37–0.79, p = 0.002) were identified as significant predictors for postoperative activity-related pain. This indicates that patients with an NRS pain score ≥ 3 on movement had a higher prevalence of poor preoperative nutrition than those with an NRS score < 3. Furthermore, the female sex was associated with an increased risk of postoperative pain and inadequate analgesia (OR = 0.66, 95% CI: 0.47–0.92, p = 0.015). In contrast, no significant difference in age was observed

between the groups (Fig. 3).

Multivariable logistic regression analysis revealed a trend wherein patients with poor preoperative nutritional status were associated with higher NRS scores for postoperative activity-related pain. Our results indicate that female sex (OR = 0.70, 95% CI: 0.48–1.0, p = 0.050), GNRI (OR = 0.50, 95% CI: 0.34–0.73, p < 0.001), and monocyte count (OR = 0.50, 95% CI: 0.30–0.81, p = 0.005) were significantly associated with the outcome between the two groups. In contrast, no significant difference in age was observed in the experimental group at 24 hours postoperatively (p = 0.869). Collectively, poor preoperative nutritional status was associated with postoperative activity-related pain among female patients following laparoscopic colorectal surgery or stoma reversal surgery.

4.3 The predictive performance of preoperative nutrition for postoperative pain may be affected by the sort of medicine of preoperative nerve block.

Secondly, Second, the analgesic agents used for preoperative nerve blocks were categorized among the enrolled patients. Specifically, 295 patients received liposomal bupivacaine in a preoperative transversus abdominis plane (TAP) block, whereas 291 patients received ropivacaine. univariable and multivariable logistic regression analyzes were also performed for these patients, based on the type of local anesthetic used in the TAP block. The results indicated that among patients who received liposomal bupivacaine, both GNRI and monocyte count were significantly higher in the weak postoperative pain group than in the strong postoperative pain group at 24 hours postoperatively. In contrast, among patients who received ropivacaine, GNRI remained significantly higher in the weak postoperative pain group than in the high-pain group. (Table 2).

Table 2
Univariable and multivariable logistic regression analysis of different medicines for preoperative nerve block

		Variable	**OR**	**CI Lower**	**CI Upper**	**p**
ropivacaine	**univariable**	**GNRI**	**0.48**	**0.29**	**0.79**	**0.004**
pca1	3.00	1.86	4.90	< 0.001		
Multiple factors	GNRI	0.43	0.26	0.73	0.002	
	pca1	3.21	1.95	5.28	< 0.001	
Liposomes	univariable	GNRI	0.40	0.25	0.66	< 0.001
		Monocyte count	0.26	0.11	0.54	< 0.001
		pca1	2.60	1.57	4.35	< 0.001
	Multiple factors	GNRI	0.50	0.30	0.84	0.008
		Monocyte count	0.30	0.14	0.66	0.003
		pca1	2.51	1.47	4.31	< 0.001

4.4 The level of preoperative nutritional indicators can guide the suitable usage of postoperative analgesia.

Thirdly, the correlation analysis revealed a strong positive association between the number of PCA demands and the NRS score for postoperative activity-related pain (OR = 3.02, p < 0.001). Patients with higher NRS scores were more likely to press the button, which may suggest inadequate analgesia (Table 1).

Meanwhile, as the number of PCA is used as a secondary outcome indicator, negative binomial regression revealed that preoperative national status and inflammatory markers were significantly associated with postoperative PCA demand, which shows the same results as the previous univariable and multivariable regression analyzes. Patients for every one-point increase in the NRS-2002, the

postoperative PCA demand would decrease 15.41% (IRR = 0.8459, 95% CI: 0.7265–0.9849, p = 0.03). CRP, a classic acute-phase reactant and key inflammation marker, showed a statistically significant association with postoperative PCA demand in the negative binomial regression analysis (IRR = 1.0091, 95% CI: 1.0006–1.0178, p = 0.04) (Table 3).

Table 3
Negative binomial regression analysis using PCA as the observational indicator

Variable	Coefficient	Std. Error	IRR	95% CI	z value	P value
(Intercept)	0.5795	1.0072	1.7852	(0.2480–12.8531)	0.575	0.565
NRS-2002	-0.1674	0.0776	0.8459	(0.7265–0.9849)	-2.156	0.031
NPS	0.0518	0.0855	1.0532	(0.8907–1.2453)	0.606	0.544
BMI	-0.0279	0.0200	0.9725	(0.9352–1.0112)	-1.400	0.162
cholesterol	0.0020	0.0747	1.0020	(0.8655–1.1599)	0.026	0.979
prealbumin	-0.0013	0.0009	0.9987	(0.9969–1.0005)	-1.378	0.168
albumin	0.0110	0.0162	1.0111	(0.9794–1.0437)	0.677	0.498
Globulin-ratio	0.2642	0.2426	1.3024	(0.8095–2.0953)	1.089	0.276
C-reactive protein	0.0091	0.0043	1.0091	(1.0006–1.0178)	2.095	0.036
Lymphocyte-count	0.1392	0.1380	1.1493	(0.8769–1.5063)	1.009	0.313
Neutrophil-count	0.0226	0.0373	1.0229	(0.9507–1.1005)	0.606	0.544
Monocyte-count	-0.1589	0.1591	0.8531	(0.6246–1.1652)	-0.999	0.317
CALLY	-0.0093	0.0060	0.9907	(0.9792–1.0024)	-1.561	0.118

Further analysis using Spearman correlation revealed that monocyte count had positively correlated with PCA (ρ = 0.0086, p = 0.8362) and negatively correlated with postoperative activity pain (ρ = -0.1074, p = 0.009) at the same time. While monocyte count had positively correlated with postoperative activity pain (ρ = 0.0034, p = 0.9341) and negatively correlated with postoperative activity pain (ρ = -0.0691, p = 0.0945) (Fig. 4).

5. Discussion

In this cohort of patients undergoing laparoscopic colorectal surgery, preoperative nutritional and inflammatory status was identified as independent predictors of postoperative acute pain. The most significant finding of our study is that patients with higher GNRI values and higher monocyte counts had a lower risk of inadequate postoperative pain relief within 24 hours after surgery compared to those with lower values. We determined that 113.8 was an optional cut-off value of GNRI in predicting postoperative activity-related pain. Furthermore, PCA count showed a strong connection with postoperative pain score,

suggesting that preoperative nutrition and inflammation may serve as an approach to adjust PCA regimens and enhance postoperative pain control.

Studies have found that preoperative malnutrition is closely associated with poor postoperative outcomes[7,8]. It was further demonstrated that patients with high nutritional risk (GNRI < 113.8) are more likely to experience inadequate postoperative pain relief, providing guidance for postoperative pain risk stratification. It is consistent with the finding of Sasaki M et al., who used a GNRI cut-off of 98[30]. GNRI integrates serum albumin and ideal body weight, which reflect the body's long-term protein reserves and energy balance, respectively. Low GNRI may indicate a state of metabolic stress by activating the neuroendocrine-immune network, and its impact can intensify over time, leading to exacerbated inflammation, metabolic disorders, and organ dysfunction[31,32].

In contrast to the conclusion of Ghasemlou N et al. that tissue-infiltrating immune cells produce inflammatory mediators such as proinflammatory cytokines (TNF, IL-1β), which elicit inflammatory pain by binding to cytokine receptors on nociceptors in muscle, skin, and joint tissues[33–35], our finding demonstrates that a low preoperative monocyte count has an independent protective effect associated with a lower NRS score. However, these divergent findings may imply functional heterogeneity among leukocyte subsets and a complex role of monocytes in pain pathways. Ming-Feng Liao et al. reported that monocyte chemoattractant protein-1 (MCP-1) participates in neuropathic pain development by attracting monocytes to accumulate at the site of injury. They further demonstrated that granulocyte-colony stimulating factor (G-CSF) can suppress MCP-1 expression through upregulating microRNA-122 in the dorsal root ganglia (DRGs) of chronic constriction injury (CCI) rats at an early stage[36,37]. Moreover, as elaborated by Siva Athithya Lakshmana Vijayarajan et al., the mature classical monocyte cluster suggests a protective role against chronic postsurgical pain (CPSP). Furthermore, the risk of CPSP decreases as the baseline level of intermediate monocytes in female patients increases (β = -0.429, 95% CI: -0.069 to -0.79, p = 0.02)[38]. The conclusion that a high monocyte count may alleviate postoperative pain extends beyond the traditional perspective that greater inflammation leads to stronger pain. This finding may indicate the involvement of specific immune cell subtypes and complex signaling pathways in postoperative recovery.

Next, we analyzed the correlation between patient-controlled analgesia (PCA) usage and the NRS score, revealing that patients with higher NRS scores (NRS ≥ 3) tended to press the button more frequently, a trend that was statistically significant. It serves not only as a result but also as an objective indicator of pain severity. A previous systematic review reported that suprathreshold heat pain has been shown to correlate positively with postoperative pain intensity and analgesic consumption in several studies[39]. Another recent prospective observational study indicated that a patient's preoperative fear and anxiety can influence the number of PCA requests[40]. Additionally, variations in preoperative pain threshold and tolerance among patients can also influence postoperative analgesic consumption[39]. A multimodal analgesia study in children demonstrated that multimodal pain management can reduce opioid

consumption and alleviate complications such as nausea, vomiting, respiratory depression, and addiction[41].

The above results of univariable and multivariable logistic regression, however, appear to contradict the results from the negative binomial regression analysis. While PCA demands reflect the patient's subjective pain through button presses within the first 24 hours after surgery, the NRS score is a more objective indicator that captures the patient's pain intensity at the specific moment of assessment. The Nutritional Risk Screening 2002 (NRS2002) comprises criteria such as unintentional weight loss occurring in the past 1–3 months, a BMI value below 20.5, and diminished appetite during the previous week. A patient with higher NRS2002 score may have lower body weight. Given that postoperative pain medications are formulated in standard dosages, it is plausible that patients with poorer nutrition (measured by the NRS-2002) might have lower PCA usage. The results of the negative binomial regression showed for each 1-unit increase in C-reactive protein, the expected number of PCA presses increases by 0.9%. This conclusion is in line with the perspective put forward by Wu LL on high preoperative CRP levels (5.0 mg/mL) are an independent predictor of poor survival after radical surgery in patients with esophageal squamous cell carcinoma[42]. Collectively, based on the findings of the current retrospective cohort study, preoperative pain sensitivity, anxiety levels, and nutritional and inflammatory indicators may help predict postoperative analgesic requirements. This information could aid in developing personalized postoperative analgesia protocols and lowering the incidence of PCA-related complications. Furthermore, clinically, there was a trend for patients with more severe postoperative pain and higher opioid consumption to have a higher incidence of complications such as nausea/vomiting ($p = 0.085$), dizziness, and hypotension, though this finding was not statistically significant.

The current study has several limitations inherent to its retrospective, single-center design. Confounders such as psychosocial factors or individual pain sensitivity is didn't rule out and partially unbalanced baseline, may have influenced the observed associations. While we adjusted for key variables, residual confounding remains. Furthermore, our pain assessment was limited to the first postoperative day. Future prospective studies should examine whether these preoperative markers also have a predictive effect on chronic postsurgical pain. Although monocyte count has demonstrated statistical significance in relation to postoperative pain, its functional role remains unclear. Future research should further investigate the molecular and cellular mechanisms of specific monocyte subsets.

In conclusion, this retrospective cohort study demonstrated a strong correlation between postoperative pain (as defined by the NRS score) and preoperative nutritional risk (assessed by GNRI), preoperative inflammation (indicated by monocyte count), and the number of PCA demands in patients undergoing laparoscopic surgery or stoma reversal surgery. In addition, lower GNRI and lower monocyte count were associated with poor postoperative pain outcomes and increased PCA utilization, indicating a greater need for analgesics to achieve pain relief.

6. Conclution

This study identified that higher Geriatric Nutritional Risk Index (GNRI) values, elevated monocyte counts, fewer patient-controlled analgesia (PCA) presses, and fewer postoperative anesthetic side effects were independently associated with a reduced risk of postoperative pain in patients undergoing laparoscopic colorectal surgery.

Abbreviations

NRS
numerical rating scale
GNRI
geriatric nutritional risk index
NRS2002
nutrition risk scale
BMI
body mass index
PCA
patient-controlled analgesia
CRC
Colorectal cancer
OR
the odds ratio
CI
confidence interval
ERAS
enhanced recovery after surgery
PNI
prognostic nutritional index
CRP
C-reactive protein
SD
standard deviation
IQR
interquartile range
ROC
Receiver operating characteristic
AUC
the area under the ROC curve
INB
intercostal nerve block
TAP

transversus abdominis plane block

Declarations

Ethics statement and consent to participate

The Clinical Research Ethic Committee of Zhejiang Cancer Hospital approved this study and the approval number is IRB-2025-1569 (IIT). The human data was in accordance with the Declaration of Helsinki in the manuscript, with the need for informed consent waived for this retrospective study. The patients involved in our study consented to participate.

Consent for publication

All the authors had consented to the publication in *BMC Medical Informatics and Decision Making*.

Competing interests

The entire authors declare no competing interests with any individual profit affiliations.

Conflict of interest

The authors have declared that no conflict of interest exists.

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Author Contribution

Shunv Cai: Methodology, Validation, Investigation, Writing - Original Draft. **Yun Chen** : Writing - Review & Editing, Supervision. **Ying Zhang:** Methodology, Validation, Investigation, Writing - Original Draft. **Ze Chai:** Formal analysis, Writing - Review & Editing. **Ziyan Weng:** Formal analysis, Writing - Review & Editing. **Xiaoying Wang:** Formal analysis, Writing - Review & Editing. **Junbo Yuan:** Formal analysis, Writing - Review & Editing.

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None.

Data Availability

Any researchers interested in this study may contact the corresponding author to request the raw data.

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Figures

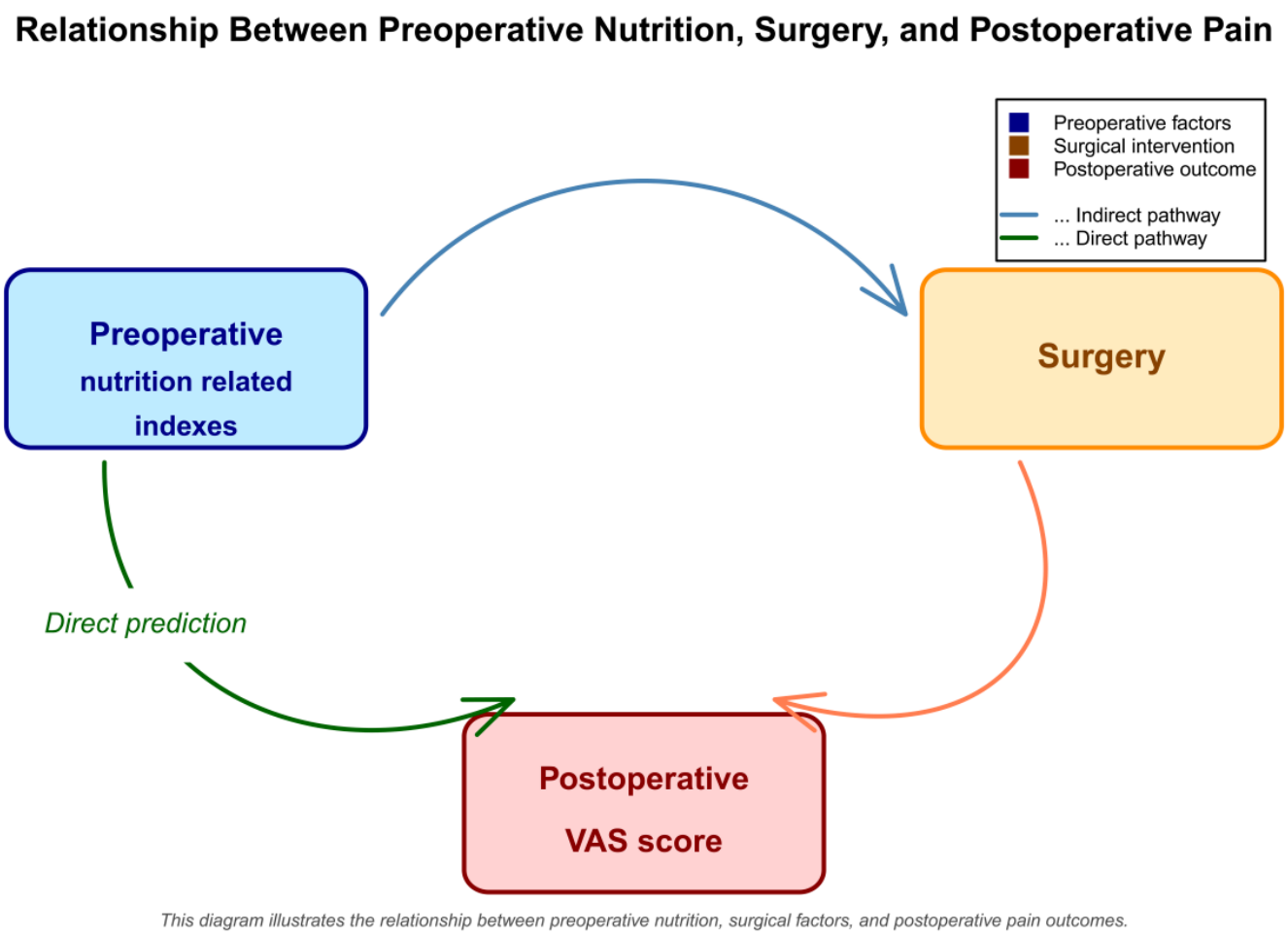


Figure 1

Relationship between preoperative nutrition, surgery and postoperative pain.

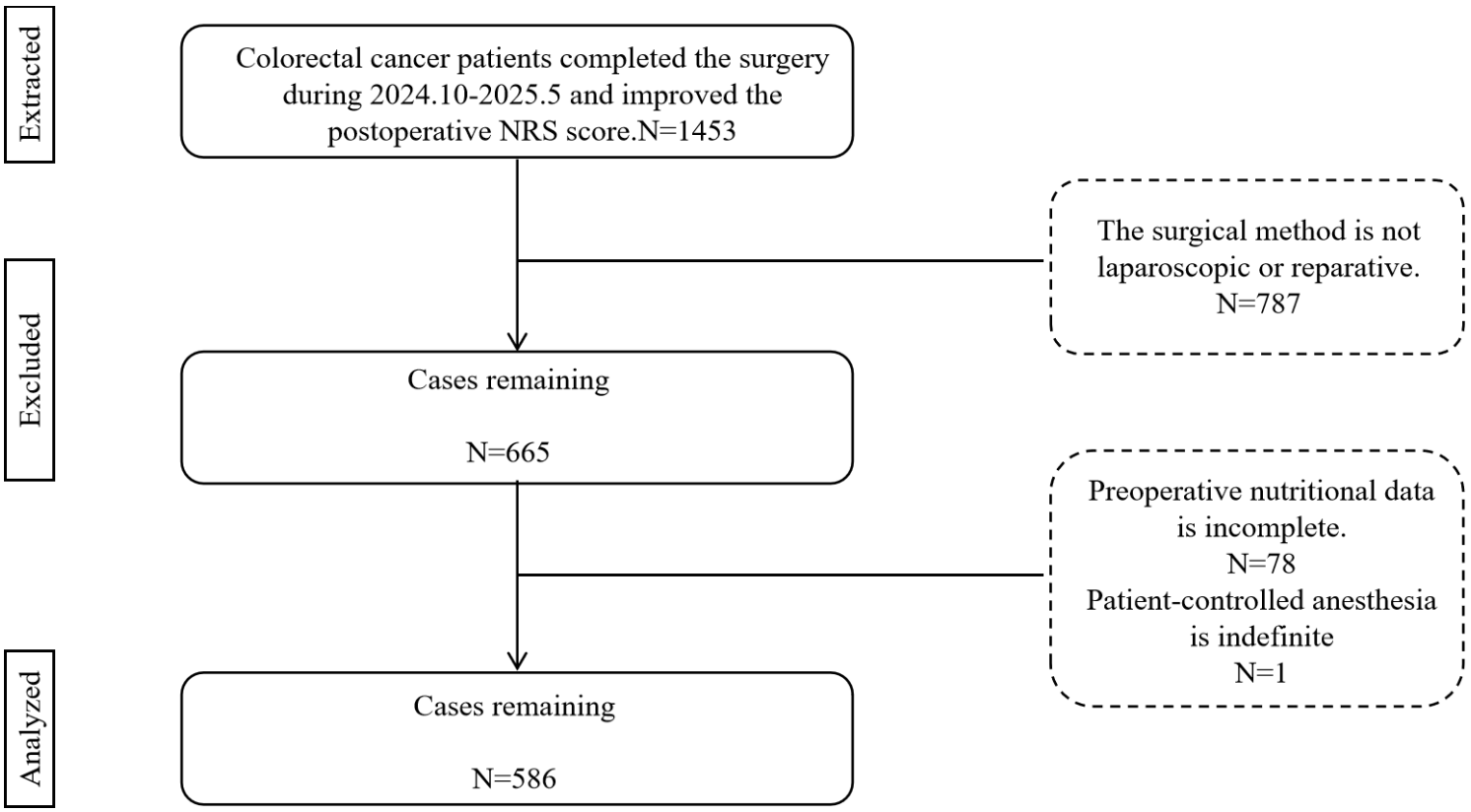


Figure 2

Study flow chart.

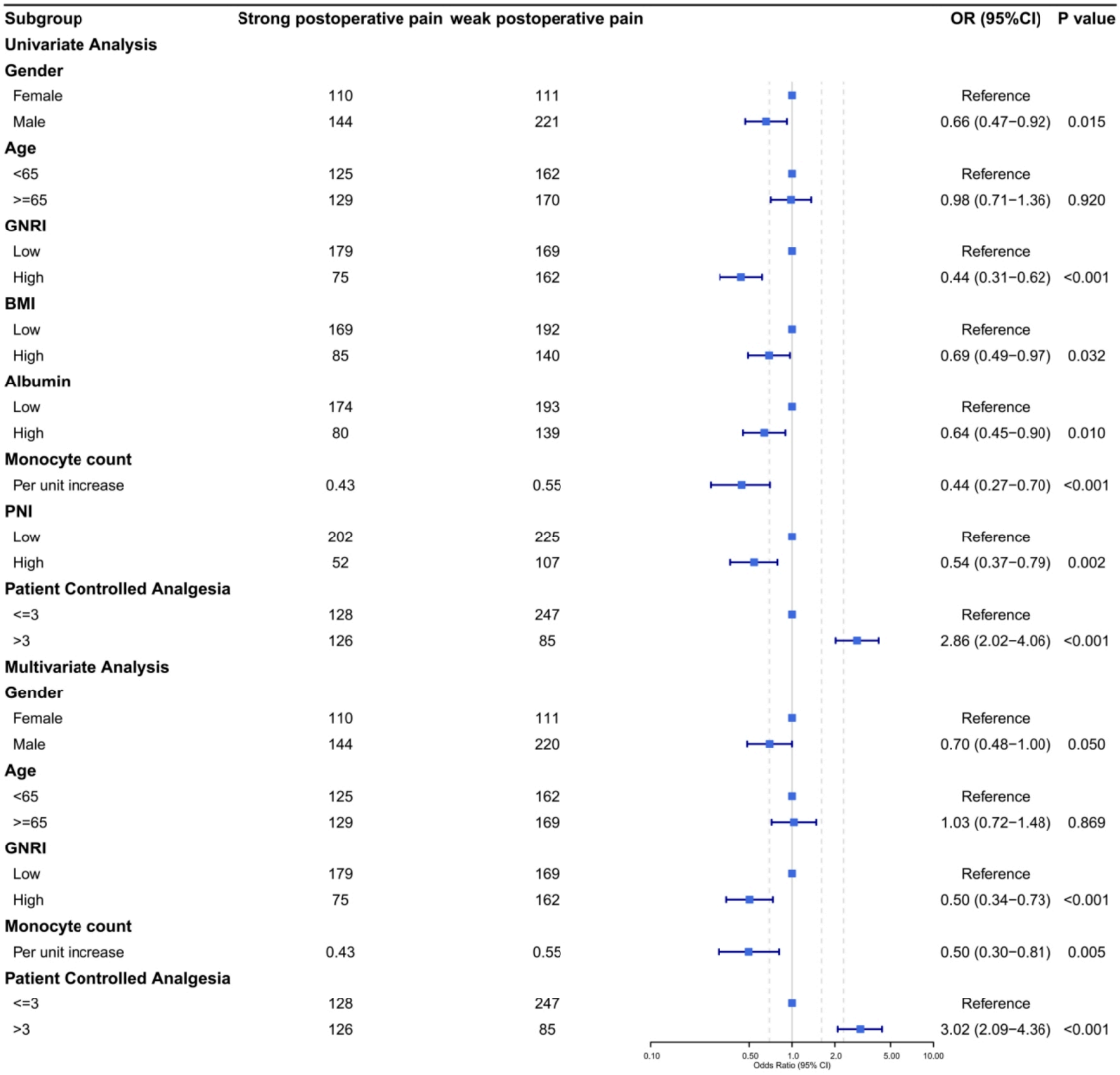


Figure 3

Univariable and multivariable logistic regression analysis of two groups and forest plot

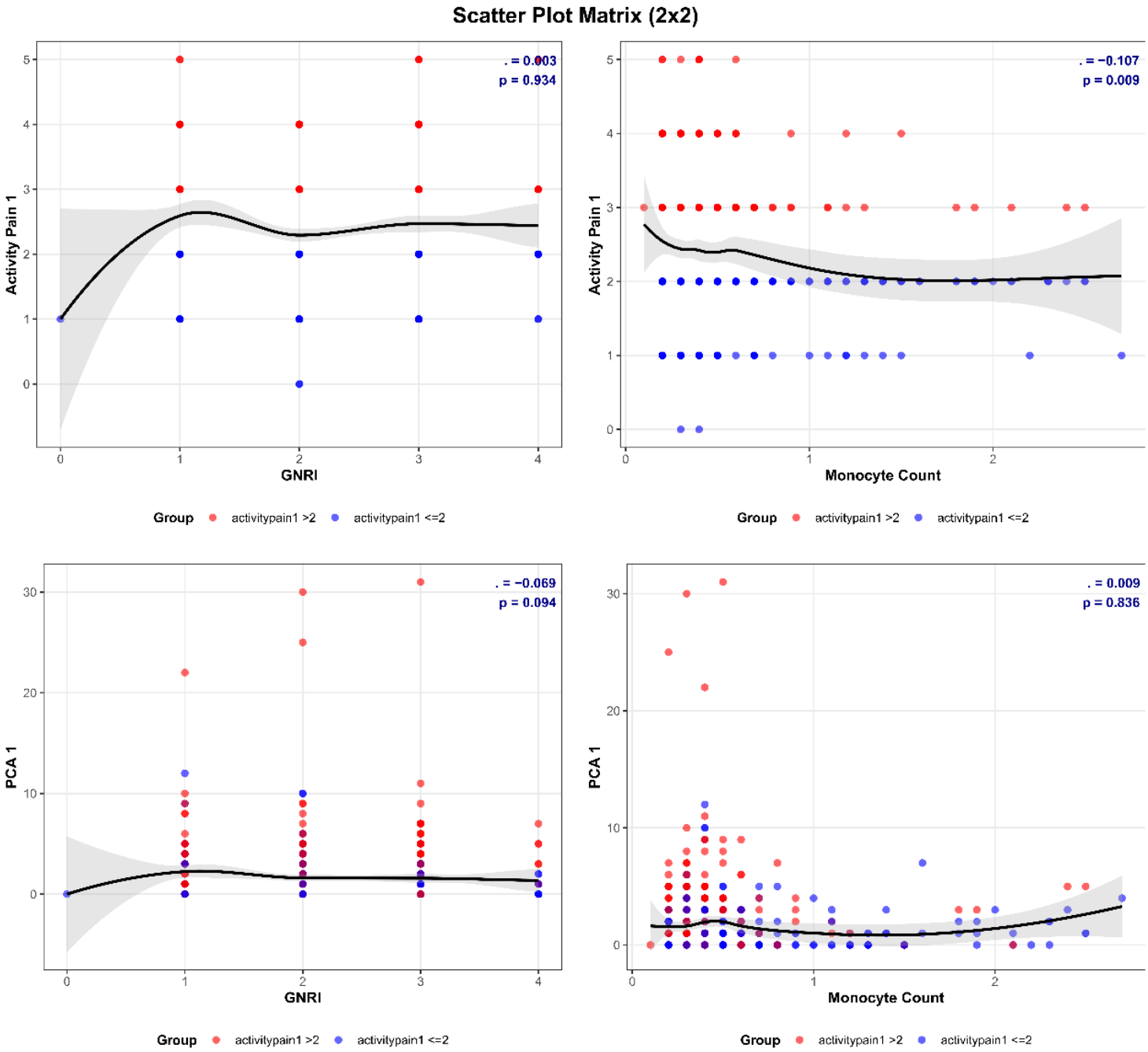


Figure 4

2x2 matrix for Spearman analysis