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Dynamic Changes and Influencing Factors of Acute Pain After Elastic Band Ligation of Internal Hemorrhoids in Patients With Mixed Hemorrhoids

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AIM: To investigate the dynamic trajectory of acute pain after elastic band ligation of internal hemorrhoids in patients with mixed hemorrhoids and to analyze the independent factors influencing the pain trajectory.

METHODS: This single-center retrospective study included 173 patients with mixed hemorrhoids (grade III or IV) who underwent elastic band ligation of internal hemorrhoids at the Department of Proctology, The People's Hospital of Tinghu District, between April 2022 and April 2025. Baseline data, preoperative Self-Rating Anxiety Scale (SAS), Self-Rating Depression Scale (SDS), Social Support Rating Scale (SSRS) scores, and visual analog scale (VAS) pain scores on postoperative days 1, 3, 7, and 14 were collected. A growing mixture model (GMM) was used to identify pain progression trajectories. Univariate and multivariate logistic regression analyses were used to identify independent factors influencing trajectory categories, and receiver operating characteristic (ROC) curves were used to assess the discriminative power of risk factors.

RESULTS: GMM analysis identified two pain progression trajectories: a rapid relief group (82 cases, 47.4%) and a poor relief group (91 cases, 52.6%). There were statistically significant differences in VAS scores at each postoperative time point and in intra-group time changes between the two groups ($p < 0.001$). Multivariate logistic regression analysis showed that age (odds ratio [OR] = 0.90, 95% confidence interval [CI]: 0.85–0.96, $p = 0.002$), SAS score (OR = 1.05, 95% CI: 1.01–1.10, $p = 0.018$), SDS score (OR = 1.05, 95% CI: 1.01–1.09, $p = 0.009$), SSRS total score (OR = 0.72, 95% CI: 0.65–0.81, $p < 0.001$), and number of ligations (OR = 4.96, 95% CI: 1.25–19.77, $p = 0.023$) were independent factors influencing the pain trajectory. ROC curve analysis showed that the area under the curve for the combination of these factors was 0.94 (95% CI: 0.91–0.97), the optimal cutoff value was 0.635, the sensitivity was 0.82, and the specificity was 0.96.

CONCLUSIONS: Postoperative pain following elastic band ligation for mixed hemorrhoids exhibits heterogeneous trajectories. Younger age, higher preoperative anxiety and depression levels, lower levels of social support, and a greater number of ligations increase the risk of patients falling into an unfavorable relief trajectory. These factors may help identify patients at risk of unfavorable postoperative pain trajectories and inform individualized postoperative pain management.

Keywords: mixed hemorrhoids; elastic band internal hemorrhoid ligation; postoperative pain; dynamic pain changes; influencing factors

Introduction

Hemorrhoids, one of the most common anorectal diseases, are characterized by pathological expansion and displacement of the anal cushion tissue and abnormal proliferation of the anorectal venous plexus [1]. Epidemiological data show that the prevalence of hemorrhoids in the adult population is as high as 40% to 60%, and the prevalence is even higher in some regions and specific populations [2]. With the Westernization of dietary habits, the popularity of sedentary lifestyles and the increase in abnormal defecation behaviors, the incidence of hemorrhoids has been on the rise [3]. Mixed hemorrhoids are one of the most common types of hemorrhoids in clinical practice, particularly circumferential mixed hemorrhoids, which result from the fusion of internal and external hemorrhoids. They are often accompanied by obvious prolapse, bleeding, pain and perianal edema, which bring a heavy burden to the daily life and psychological well-being of patients [4].

For patients with mixed hemorrhoids who have obvious symptoms and poor response to conservative treatment, surgical treatment is one of the most effective options for eradicating hemorrhoids in clinical practice [5]. Traditional external excision and internal ligation for mixed hemorrhoids is technically simple and clinically effective, but it is associated with considerable surgical trauma, significant postoperative pain, prolonged recovery period, and a high incidence of complications. Procedure for Prolapse and Hemorrhoids (PPH), an early minimally invasive surgical tech-

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nique, has the potential to reduce pain and shorten recovery time; however, due to its technical complexity and the risk of postoperative complications, it has gradually been replaced by other surgical methods [6,7]. In recent years, automatic rubber band ligation (RBL) has gradually become one of the effective minimally invasive methods for treating mixed hemorrhoids [8]. RBL uses elastic bands to ligate the base of internal hemorrhoids, causing ischemic necrosis and subsequent sloughing of the hemorrhoidal tissue, while also lifting the anal cushion tissue to achieve hemostasis and improve prolapse [9]. Compared with traditional surgery, RBL has advantages, including simple operation, less tissue damage, faster recovery and shorter hospital stay. It has been widely used in the treatment of patients with grade 2 to 3 hemorrhoids, and has shown favorable safety and effectiveness [10,11].

However, postoperative pain remains one of the most common complications and a core concern for patients undergoing RBL. A study has shown that nearly half of patients experience varying degrees of pain within 24 to 48 hours after RBL, with mild to moderate pain being the most common, and a few patients may experience severe pain requiring further intervention [12]. A series of studies have also suggested that the risk of postoperative pain may be related to the location of the ligation point, the number of loops, and individual patient-related factors; however, a standardized strategy for postoperative pain management has yet to be established [13,14,15]. Postoperative pain is not just a physiological experience; it may also lead to increased postoperative anxiety, defecation phobia, functional anal sphincter spasm, and other problems, thus becoming an important factor affecting the quality of postoperative recovery and quality of life [16]. The mechanisms underlying pain mainly include hypersensitivity caused by the dense distribution of somatic sensory nerve below the dentate line, central sensitization resulting from the postoperative release of local inflammatory mediators, and persistent pain related to anal sphincter tension and defecation stimulation [17]. Furthermore, the strategies for managing postoperative pain vary. Some studies have attempted the use of intraoperative local anesthesia to reduce short-term postoperative pain, while others have emphasized the importance of postoperative analgesia management. However, overall evidence remains limited.

Given the above background, although RBL has become one of the important minimally invasive surgical procedures for treating mixed hemorrhoids, systematic studies on the dynamic changes and influencing factors of postoperative acute pain are still relatively lacking. Most existing studies have primarily focused on comparing the overall incidence of surgical procedures and complications, or have simply reported the incidence of postoperative pain, but systematic analyses of the temporal distribution of pain, patient characteristics, surgical factors, and the patterns in pain intensity changes remain scarce. Therefore, an in-depth investigation of the dynamic changes and potential influencing factors of postoperative pain in patients with mixed hemorrhoids undergoing RBL will not only help refine perioperative analgesia strategies but also provide evidence-based support for developing individualized postoperative management plans and improving patient comfort and satisfaction.

Based on this, the present study analyzes the dynamic changes in acute pain after elastic band ligation of internal hemorrhoids in patients with mixed hemorrhoids and explores clinical and surgical factors that may be related to pain intensity. This study aims to provide new insights into pain management after elastic band ligation and theoretical support for optimizing postoperative analgesic strategies.

Methods

Participants

This study was a single-center retrospective study. Clinical data from patients with mixed hemorrhoids who underwent elastic ligation of internal hemorrhoids at the Department of Proctology, The People's Hospital of Tinghu District from April 2022 to April 2025 were retrospectively collected. All patients were clearly diagnosed with mixed hemorrhoids (grade III or IV) and completed standardized perioperative treatment and postoperative follow-up. Selected patients with grade IV hemorrhoids were included when they were unable or unwilling to undergo conventional surgical treatment and were considered suitable for RBL after clinical assessment. The study protocol was reviewed and approved by the hospital’s ethics committee. Inclusion criteria for patients: (1) Patients diagnosed with mixed hemorrhoids grade III or IV according to the Goligher clinical classification system for hemorrhoids; (2) Patients with obvious clinical symptoms (such as recurrent rectal bleeding, prolapse, pain or anal discomfort) that affect their quality of life; (3) Patients who did not respond well to standardized conservative treatment (including dietary adjustments and drug treatment) or who had recurrent relapses; (4) Patients who could tolerate surgical treatment and demonstrated good compliance; (5) Patients who completed elastic ligation of internal hemorrhoids and had complete perioperative data; (6) Patients with complete follow-up records for at least 14 days postoperatively. Patients meeting any of the following criteria were excluded: (1) those with a history of mixed hemorrhoid surgery or other perianal disease surgery; (2) those with serious systemic diseases or serious primary diseases (such as serious cardiovascular diseases, cerebrovascular diseases, liver and kidney dysfunction or hematopoietic system diseases); (3) those with serious mental illnesses (such as severe depression and mania) that affect the accuracy of pain assessment; (4) those with rectal cancer, inflammatory bowel disease (such as Crohn’s disease), rectal tuberculosis or other serious anorectal diseases; (5) those with missing perioperative data or who did not complete postoperative follow-up; (6) those with a history of pelvic radiotherapy; (7) those who had received sclerotherapy injections for hemorrhoids within the preceding 3 months; (8) pregnant women; (9) patients with poorly controlled diabetes mellitus.

The study was approved by the Ethics Committee of The People's Hospital of Tinghu District (approval number: 2025-SR-036), and all procedures followed the principles of the Declaration of Helsinki. As this was a retrospective observational study involving only previously collected clinical diagnoses and treatment data, no additional interventions were introduced, and no risks were posed to patients' diagnostic or therapeutic processes or privacy rights. Therefore, the requirement for written informed consent was waived with approval from the hospital ethics committee.

Baseline Data Collection

This study retrospectively collected baseline clinical data of patients through the hospital's electronic medical record system and inpatient medical record management system. The collected data mainly included the following: (1) General demographic data: age and gender; (2) Physical indicators: body mass index (BMI), calculated by dividing weight (kg) by height (m^2); (3) Perioperative indicators: length of hospital stay. A length of hospital stay of 0 days indicates same-day discharge without an overnight stay; (4) Personal behavioral factors: smoking history and drinking history. Smoking was defined as current smokers or those who have smoked continuously for ≥6 months; drinking was defined as those who drink alcohol ≥3 times per week for ≥6 months; (5) Comorbidities: chronic underlying diseases such as hypertension, diabetes, and coronary heart disease, based on previous clear diagnostic records; (6) Surgical-related factors: number of ligations, counted according to the actual number of ligation points recorded in the medical record.

Patient's Anxiety Status

The perioperative anxiety level was assessed using the Self-Rating Anxiety Scale (SAS) one day before surgery. The SAS, developed by Zung [18], consists of 20 items rated on a 4-point rating scale (1 to 4 points), corresponding to "none or rarely", "sometimes", "frequently", and "almost always", respectively. The scores for each item were summed to obtain the raw total score, which was then multiplied by 1.25 and rounded to the nearest whole number to obtain the standard score.

Patient's Depression Status

The Self-Rating Depression Scale (SDS) was used to assess the perioperative depressive status of patients. The SDS, also developed by Zung et al. [19], consists of 20 items rated on a 4-point scale (1–4 points). Among the 20 items, 10 are positively worded and 10 are negatively worded (reverse-scored). The raw total score was obtained by summing the scores of each item, multiplying it by 1.25, and rounding it down to the nearest whole number as the standard score. In this study, the standard SDS scores obtained one day before surgery were extracted from medical records and used to analyze their correlation with the severity of acute postoperative pain.

Patient's Level of Social Support

The level of social support was assessed using the Social Support Rating Scale (SSRS). This scale, developed by Xiao SY [20], incorporates assessment of support utilization in addition to objective and subjective support, making it more consistent with the Chinese cultural context. The scale comprises 10 items, including three dimensions: subjective support (items 1, 3, 4, 5), objective support (items 2, 6, 7), and utilization of support (items 8, 9, 10). The Cronbach's α coefficients for each dimension are 0.849, 0.825, and 0.833, respectively, indicating good reliability [21].

The total score of the scale ranges from 12 to 66 points, with higher scores indicating a higher level of social support received by the individual. In this study, patients' total preoperative social support scores and subscale dimension scores were extracted and included in subsequent statistical analysis to explore the relationship between the levels of social support and the dynamic changes in postoperative acute pain.

Postoperative Pain Index

The severity of acute postoperative pain was assessed using the visual analogue scale (VAS) [22]. The VAS score ranges from 0 to 10, where 0 indicates "no pain" and 10 indicates "unbearable severe pain". The higher the score, the more severe the pain.

Pain assessments were conducted on postoperative days 1, 3, 7, and 14. VAS scores on days 1 and 3 were completed under the guidance of trained medical staff; VAS scores on days 7 and 14 were collected through outpatient visits or telephone follow-up. All patients self-reported their pain levels based on their average pain experienced over the past 24 hours while at rest. To ensure data accuracy and consistency, all medical staff involved in pain assessment received standardized training and strictly followed the standardized instructions when explaining the scoring method to patients, avoiding any leading prompts. All VAS score data were fully recorded in the medical record system or follow-up records and used to analyze the dynamic trends of postoperative pain and its related influencing factors. All patients in this study underwent the procedure in an outpatient operating room. Routine monitoring, including blood pressure, heart rate, and oxygen saturation, was performed throughout the procedure. Submucosal local anesthetic (lidocaine infiltration around the ligation site) was routinely administered prior to banding. Ligation was performed at the base of the hemorrhoidal mass, approximately 1.0 cm above the dentate line. The number of ligations per session was determined based on the degree of prolapse and the number of hemorrhoidal columns, generally ranging from 2 to 4, with up to 5–6 in selected cases.

Postoperatively, all patients received oral nonsteroidal anti-inflammatory drugs (NSAIDs) or acetaminophen as needed for pain relief. In addition, routine analgesic medication was administered within the first 24 hours after surgery, and rescue analgesia was given according to the patient's reported pain intensity. The attending physician adjusted the analgesic regimen individually. Patients were instructed to avoid excessive straining during defecation, maintain a high-fiber diet, ensure adequate hydration, and use stool softeners when necessary. Sitz baths were offered to relieve local discomfort.

Statistical Analysis

This study used SPSS 26.0 (IBM Corp., Armonk, NY, USA), R software 4.3.3 (R Foundation for Statistical Computing, Vienna, Austria), and RStudio v.5.12.10 (Posit Software, PBC, Boston, MA, USA) for data processing and statistical analysis. First, descriptive statistical analysis was performed. Continuous variables were assessed for normality using the Kolmogorov–Smirnov test. Normally distributed data were expressed as mean ± standard deviation ($\bar{x} \pm s$), and independent samples *t*-tests were used for intergroup comparisons. Data not normally distributed were expressed as median (interquartile range), and Mann–Whitney U tests were used for intergroup comparisons. Categorical variables were expressed as frequencies and percentages, and χ^2 tests or Fisher's exact tests were used for intergroup comparisons. All tests were two-tailed, and $p < 0.05$ was considered statistically significant.

To identify the potential heterogeneous trajectory of dynamic pain changes after elastic band ligation in patients with mixed hemorrhoids, this study used a growth mixture model (GMM) for latent category analysis. Pain scores measured using VAS scores at 1, 3, 7, and 14 days post-surgery were included in the model as repeated measures indicators. GMM analysis was performed in the R language environment (version 4.3.3, R Core Team, R Foundation for Statistical Computing, Vienna, Austria) using the lcmm (version 2.1.0), OpenMx (version 2.21.8), and flexmix (version 2.3-19) packages, primarily based on a latent variable mixture modeling framework. The model started with a single class (1-class) and gradually increased the number of classes, fitting 2-class and 3-class models respectively.

Model goodness of fit was compared using the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and adjusted BIC (aBIC), with lower values indicating better model fit. The Lo-Mendell-Rubin Likelihood Ratio (LMR) was used to assess whether the K-class model significantly outperformed the K−1 model ($p < 0.05$ indicated statistically significant improvement). Furthermore, entropy was used to evaluate classification accuracy, with values closer to 1 indicating higher accuracy. Based on these statistical indicators and the clinical interpretability of trajectory morphology, the optimal number of classes was determined.

After determining the optimal pain trajectory category, patients were assigned to the corresponding category based on their maximum posterior probability. Univariate analysis was then used to compare baseline characteristics between different trajectory categories. Variables for the multivariate logistic regression were selected using backward stepwise regression (likelihood ratio test, entry and removal thresholds $p < 0.10$). Odds ratios (ORs) and 95% confidence intervals (95% CIs) were calculated for each variable. The variance inflation factor (VIF) was calculated to assess multicollinearity among continuous independent variables. Covariates included in the model were age, sex, BMI, smoking history, alcohol consumption history, comorbidities, number of ligations, SAS score, SDS score, and social support score.

All statistical analyses were two-tailed tests, and $p < 0.05$ was considered statistically significant.

Results

Patient Demographic and Sociological Characteristics

This study ultimately included 173 patients with mixed hemorrhoids who underwent elastic band ligation for internal hemorrhoids. The basic information of the patients is shown in Table 1.

Identification and Determination of the Trajectory of Postoperative Pain

The fit of postoperative pain scores at rest on days 1 (T1), 3 (T2), 7 (T3), and 14 (T4) was evaluated to identify potential postoperative pain trajectory categories (**Supplementary Table 1**). When the pain trajectory was divided into two categories, the AIC, BIC, and aBIC values of the GMM were all lower than those of the single-category model, and the Lo-Mendell-Rubin Likelihood Ratio Test (LMR-LRT) test reached statistical significance ($p < 0.001$), indicating that the two-category model provided a superior fit compared to the single-category model. When the postoperative pain trajectory was divided into three categories, the AIC, BIC, and aBIC values were all higher than those of the two-category model, and the LMR-LRT test did not reach statistical significance ($p = 0.44$). Therefore, the three-category model was not superior compared with the two-category model (Table 2). In summary, the optimal model is the two-category model. The model fit indices for each category are shown in Table 2. Based on the GMM analysis, two different trajectories of postoperative pain development were identified (Fig. 1). Category 1: Patients in this group experienced moderate pain on postoperative day 1, followed by a rapid decrease in pain scores, reaching a low level by postoperative day 14. This group was designated the "rapid relief group", comprising 47.4% of the sample (n = 82). Category 2: Patients in this group experienced severe pain

Table 1. Patient baseline information.

Variables	Data
Age (years)	49.80 (43.36, 54.90)
BMI (kg/m^2)	23.90 (22.40, 25.20)
Gender, n (%)	
Female	65 (37.57)
Male	108 (62.43)
SAS	42.65 ± 12.59
SDS	44.80 ± 13.46
SSRS	
Objective support	10.36 (7.56, 11.90)
Subjective support	20.44 (17.44, 23.71)
Support utilization	7.60 (6.00, 9.08)
SSRS-total	37.11 (33.45, 43.06)
Length of hospital stay (days)	1.00 (0.00, 2.00)
Smoking history, n (%)	
Yes	33 (19.08)
No	140 (80.92)
Drinking history, n (%)	
Yes	26 (15.03)
No	147 (84.97)
Hypertension, n (%)	
Yes	75 (43.35)
No	98 (56.65)
Diabetes, n (%)	
Yes	55 (31.79)
No	118 (68.21)
Dyslipidemia, n (%)	
Yes	22 (12.72)
No	151 (87.28)
Number of ligations, n (%)	
2	40 (23.12)
3	78 (45.09)
4	55 (31.79)

BMI, body mass index; SAS, Self-Rating Anxiety Scale; SDS, Self-Rating Depression Scale; SSRS, Social Support Rating Scale.

on postoperative day 1. While pain scores fluctuated during the follow-up period, they remained at a relatively high level, showing a gradual and slow decline. This group was designated the "poor relief group", comprising 52.6% of the sample (n = 91).

Validation Analysis of the Pain-Development Trajectory

In the following comparative analyses, the two trajectory categories defined in the Section of "Identification and Determination of the Trajectory of Postoperative Pain" were used: the rapid relief group (n = 82) and the poor relief group (n = 91). Repeated measures analysis of variance (ANOVA) showed that the interaction between time points and categories was statistically significant (F = 13.65, $p <$ 0.001). Further simple effects analysis revealed significant between-group differences in pain scores at all postoperative time points ($p < 0.001$), as well as significant within-group differences in pain scores across different time points in each group ($p < 0.001$). The results of the simple effects analysis are shown in Table 3.

Comparison of Baseline Data Between the Two Groups of Patients

Among the 173 patients who underwent surgery for mixed hemorrhoids, the 82 patients in the rapid relief group had a significantly higher median age (52.09 years) than the 91 patients in the poor relief group ($p < 0.001$), based on their pain relief. There was a significant difference in gender distribution between the two groups ($p < 0.001$). Preoperative SAS and SDS scores were significantly higher in the poor relief group than in the rapid relief group ($p < 0.001$). Regarding social support, the rapid relief group showed significantly better results in subjective support, objective support, support utilization, and total score than the poor relief group (all $p < 0.001$). There were no significant differences in length of hospital stay, smoking and alcohol consumption history, or BMI between the two groups. The prevalence of hypertension was higher in the poor relief group than in the rapid relief group (50.55% vs 35.37%, $p = 0.044$), while there were no significant differences in the prevalence of diabetes or dyslipidemia between the two groups. The number of ligations during surgery differed between the two groups ($p < 0.001$), with the proportion of patients with 4 ligations (42.86%) in the poor relief group being significantly higher than that in the rapid relief group (19.51%) (Table 4).

Univariate and Multivariate Logistic Regression

Using pain trajectory category as the dependent variable, variables from baseline data and clinically relevant factors were included in a univariate logistic regression analysis. Univariate analysis showed that gender, hypertension, number of ligations, age, SAS score, SDS score, and SSRS total score were significantly associated with poor remission trajectories; while factors such as length of hospital stay, BMI, smoking history, alcohol consumption history, diabetes, and dyslipidemia were not associated with trajectory category.

Variables were selected using backward stepwise regression. The VIF values for the continuous variables were all below 5. The results showed that age, SAS score, SDS score, SSRS total score, and number of ligations were independent influencing factors for pain trajectory categories (Table 5). Specifically, younger age, higher anxiety and depression scores, lower levels of social support, and a greater number of ligations were associated with a higher risk of patients belonging to an adverse pain relief trajectory. Gender and hypertension were not statistically significant in the multivariate model.

Table 2. GMM fit index of pain development trajectory.

Number of categories	AIC	BIC	aBIC	entropy	LMR-LRT (*p*)	Minimum class proportion (%)
1	2823.64	2842.56	2823.56	1	-	100.0
2	2808.95	2837.33	2808.83	0.72	<0.001	47.4
3	2813.28	2851.12	2813.12	0.56	0.44	23.1

Minimum class proportion represents the percentage of the smallest class within each model. GMM, growing mixture model; AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion; aBIC, adjusted BIC; LMR-LRT, Lo-Mendell-Rubin Likelihood Ratio Test.

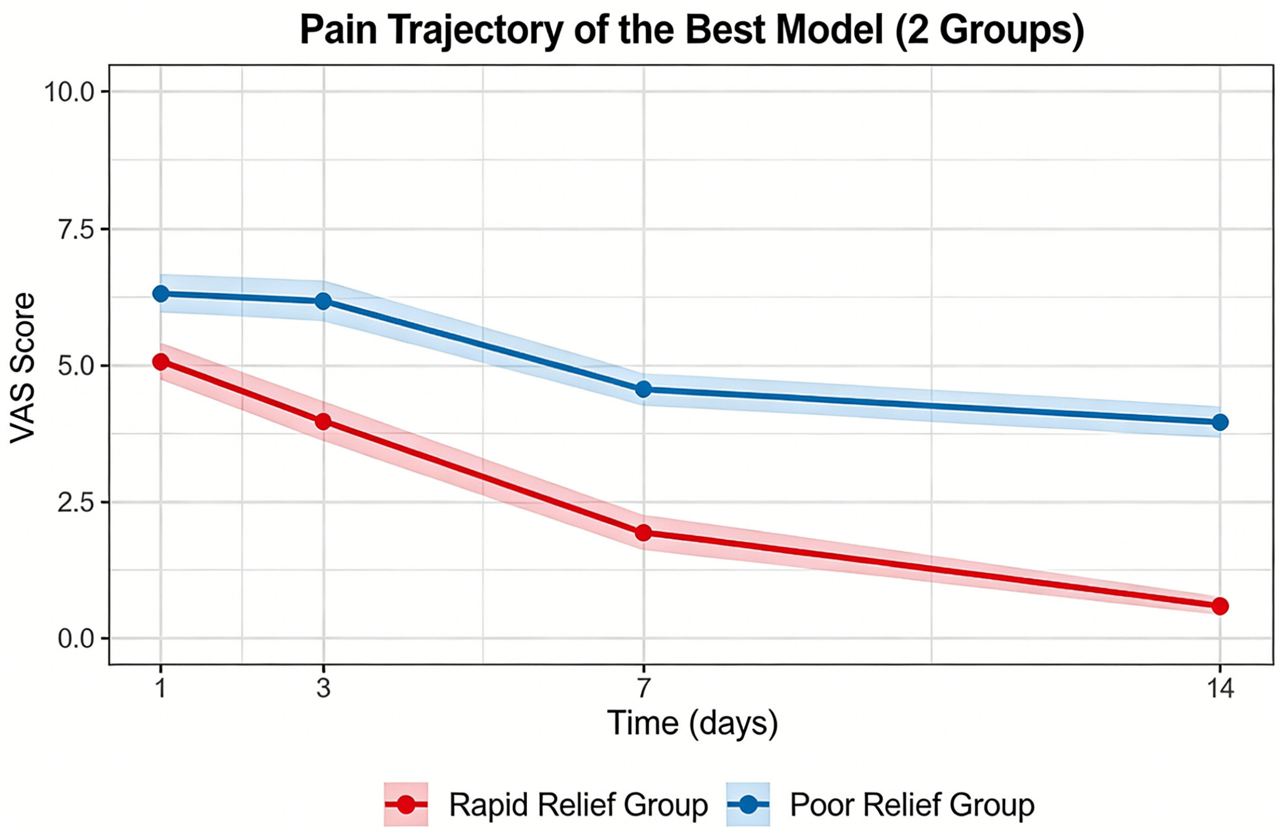

Fig. 1. Model-estimated pain trajectories for the two GMM-derived classes (the rapid relief group and the poor relief group). Values are predicted mean VAS scores. GMM, growing mixture model; VAS, visual analogue scale.

Table 3. Verification analysis of the pain trajectory.

	Category	Statistic	*p*
Within-group comparison			
	Rapid relief group	F = 146.31	<0.001
	Poor relief group	F = 66.36	<0.001
Between-group comparison			
	T1	Z = –4.60	<0.001
	T2	Z = –7.47	<0.001
	T3	Z = –6.82	<0.001
	T4	Z = –10.80	<0.001
Time × Class		F = 13.65	<0.001

Discriminative Ability of the Combined Factors

The independent influencing factors identified by multivariate logistic regression were combined to assess their discriminative ability for the poor relief trajectory using receiver operating characteristic (ROC) curve analysis. The results showed that the area under the curve (AUC) was 0.94 (95% CI: 0.91–0.97), indicating excellent discriminative ability. The optimal cutoff value was determined to be

Table 4. Comparison of baseline data between the two groups of patients.

Variables	Rapid relief group (n = 82)	Poor remission group (n = 91)	Statistic	*p*
Age (years)	52.09 (48.24, 55.44)	47.01 (39.15, 53.96)	Z = –3.90	<0.001
BMI (kg/m^2)	23.80 (22.42, 25.08)	24.00 (22.40, 25.25)	Z = –0.41	0.680
Gender, n (%)			χ^2 = 10.26	0.001
Female	41 (50.00)	24 (26.37)		
Male	41 (50.00)	67 (73.63)		
SAS	38.27 ± 12.30	46.59 ± 11.56	*t* = –4.58	<0.001
SDS	40.64 ± 11.70	48.55 ± 13.90	*t* = –4.03	<0.001
SSRS				
Objective support	11.33 (9.61, 12.91)	8.53 (6.31, 10.80)	Z = –5.96	<0.001
Subjective support	23.62 (19.98, 25.89)	18.73 (16.74, 20.79)	Z = –6.41	<0.001
Support utilization	8.47 (6.97, 9.45)	7.03 (4.94, 8.37)	Z = –4.29	<0.001
SSRS-total	43.06 (38.28, 46.50)	34.96 (30.86, 36.76)	Z = –8.44	<0.001
Length of hospital stay	1.00 (0.25, 2.00)	1.00 (0.50, 3.00)	Z = –0.31	0.753
Smoking history, n (%)			χ^2 = 0.06	0.804
Yes	15 (18.29)	18 (19.78)		
No	67 (81.71)	73 (80.22)		
Drinking history, n (%)			χ^2 = 0.32	0.573
Yes	11 (13.41)	15 (16.48)		
No	71 (86.59)	76 (83.52)		
Hypertension, n (%)			χ^2 = 4.05	0.044
Yes	29 (35.37)	46 (50.55)		
No	53 (64.63)	45 (49.45)		
Diabetes, n (%)			χ^2 = 1.01	0.316
Yes	23 (28.05)	32 (35.16)		
No	59 (71.95)	59 (64.84)		
Dyslipidemia, n (%)			χ^2 = 1.23	0.267
Yes	8 (9.76)	14 (15.38)		
No	74 (90.24)	77 (84.62)		
Number of ligations, n (%)			χ^2 = 17.50	<0.001
2	29 (35.37)	11 (12.09)		
3	37 (45.12)	41 (45.05)		
4	16 (19.51)	39 (42.86)		

0.635 based on the maximum value of the Youden index, corresponding to a sensitivity of 0.82 and a specificity of 0.96, suggesting that these factors have good discriminative ability in identifying patients at risk of poor pain relief (Fig. 2).

Discussion

This study analyzed the pain characteristics of patients with mixed hemorrhoids within 14 days after elastic band ligation. The results showed that postoperative pain did not exhibit a single linear decline, but instead followed different development patterns, indicating significant differences in recovery among patients. Trajectory model analysis identified two latent categories, with one group experiencing gradual pain relief postoperatively, while another maintained a relatively high level of pain throughout the observation period. Significant differences in pain scores were observed between the two categories at various postoperative time points, particularly in the early postoperative stage, suggesting that the first few days postoperatively may be a critical window for pain differentiation. The proportion of patients in the poor relief trajectory was substantial, indicating that some patients face complex challenges in postoperative pain management during recovery. This group exhibited high pain levels as early as day 1 postoperatively, with limited subsequent decreases, remaining in the moderate intensity range until day 14. In contrast, the group with rapid pain relief showed significant improvement from day 3 to 7 postoperatively. These differences suggest that postoperative pain control varies considerably among individuals, and a single standardized analgesia regimen may not be sufficient to meet the needs of all patients.

In the analysis of influencing factors, there was a significant association between the number of ligations and the distribution of pain trajectory. Patients with more bandings were more likely to enter the category of sustained high pain. Multiple bandings mean a wider area of mucosal ischemia and necrosis, and the degree of local tis-

Table 5. Results of univariate and multivariate logistic regression.

Variables	Univariable analysis					Multivariable analysis				
	β	SE	Z	*p*	OR (95% CI)	β	SE	Z	*p*	OR (95% CI)
Length of hospital stay	0.04	0.14	0.33	0.745	1.05 (0.80~1.36)					
Gender										
Female					1.00 (Reference)					1.00 (Reference)
Male	1.03	0.32	3.16	0.002	2.79 (1.48~5.27)	0.96	0.52	1.85	0.064	2.60 (0.94~7.18)
Smoking history										
Yes					1.00 (Reference)					
No	–0.10	0.39	–0.25	0.804	0.91 (0.42~1.94)					
Drinking history										
Yes					1.00 (Reference)					
No	–0.24	0.43	–0.56	0.573	0.78 (0.34~1.82)					
Hypertension										
Yes					1.00 (Reference)					1.00 (Reference)
No	–0.62	0.31	–2.00	0.045	0.54 (0.29~0.99)	–0.90	0.52	–1.75	0.080	0.41 (0.15~1.11)
Dyslipidemia										
Yes					1.00 (Reference)					
No	–0.52	0.47	–1.10	0.271	0.59 (0.24~1.50)					
Diabetes										
Yes					1.00 (Reference)					
No	–0.33	0.33	–1.00	0.316	0.72 (0.38~1.37)					
Number of ligations										
2					1.00 (Reference)					1.00 (Reference)
3	1.07	0.42	2.55	0.011	2.92 (1.28~6.66)	0.54	0.63	0.86	0.391	1.71 (0.50~5.82)
4	1.86	0.46	4.03	<0.001	6.43 (2.60~15.90)	1.60	0.71	2.27	0.023	4.96 (1.25~19.77)
Age	–0.08	0.02	–3.81	<0.001	0.92 (0.89~0.96)	–0.10	0.03	–3.08	0.002	0.90 (0.85~0.96)
BMI	0.04	0.09	0.41	0.680	1.04 (0.87~1.24)					
SAS	0.06	0.01	4.16	<0.001	1.06 (1.03~1.09)	0.05	0.02	2.36	0.018	1.05 (1.01~1.10)
SDS	0.05	0.01	3.73	<0.001	1.05 (1.02~1.08)	0.05	0.02	2.62	0.009	1.05 (1.01~1.09)
SSRS	–0.31	0.05	–6.75	<0.001	0.73 (0.67~0.80)	–0.32	0.06	–5.75	<0.001	0.72 (0.65~0.81)

SE, standard error; OR, odds ratio; CI, confidence interval.

sue edema and inflammatory response may increase accordingly, while sphincter reflex spasm may also be more obvious [23]. This multi-site wound stimulation further amplifies the traction discomfort during defecation, thereby prolonging the pain recovery. Therefore, while ensuring therapeutic efficacy, reasonable assessment of the number of ligations applied per session, or the development of individualized treatment plans based on the patient-specific situations, may help optimize the postoperative outcomes and improve patient experience. In the multivariate model, age was also confirmed as an independent factor influencing pain trajectory. The results of this study showed that increased age was significantly associated with a reduced risk of entering the "poor relief group"; that is, older patients were more likely to enter the rapid pain relief trajectory. From a physiological perspective, aging is characterized by a decline in the ability to maintain homeostasis and a reduced capacity to recover physiological reserves in response to stress (including surgical stress). However, these physiological changes are accompanied by alterations in pain perception mechanisms. Previous research has suggested that with increasing age, the sensitivity of afferent somatic sensory nerves decreases, the density of peripheral receptors decreases, and the central nervous system integration of pain stimuli is also modified [24]. This decrease in nerve sensitivity may lead older individuals to report relatively lower subjective pain scores when facing the same degree of tissue damage. In addition, older patients often have a stronger ability to adapt to chronic discomfort, and long-term life experience may contribute to a milder cognitive evaluation of pain, thus showing a more rapid "relief" trend in the scale scores. This finding suggests that age-related perceptual differences should be considered in the postoperative pain assessment process. For younger patients, pain education and psychological counseling should be appropriately strengthened; while for older patients, it is necessary to make a comprehensive assessment based on objective wound conditions and avoid underestimating potential discomfort solely based on lower VAS scores.

Preoperative emotional state was also associated with postoperative pain in this study. Patients with higher anxiety and depression scores were more likely to be classified

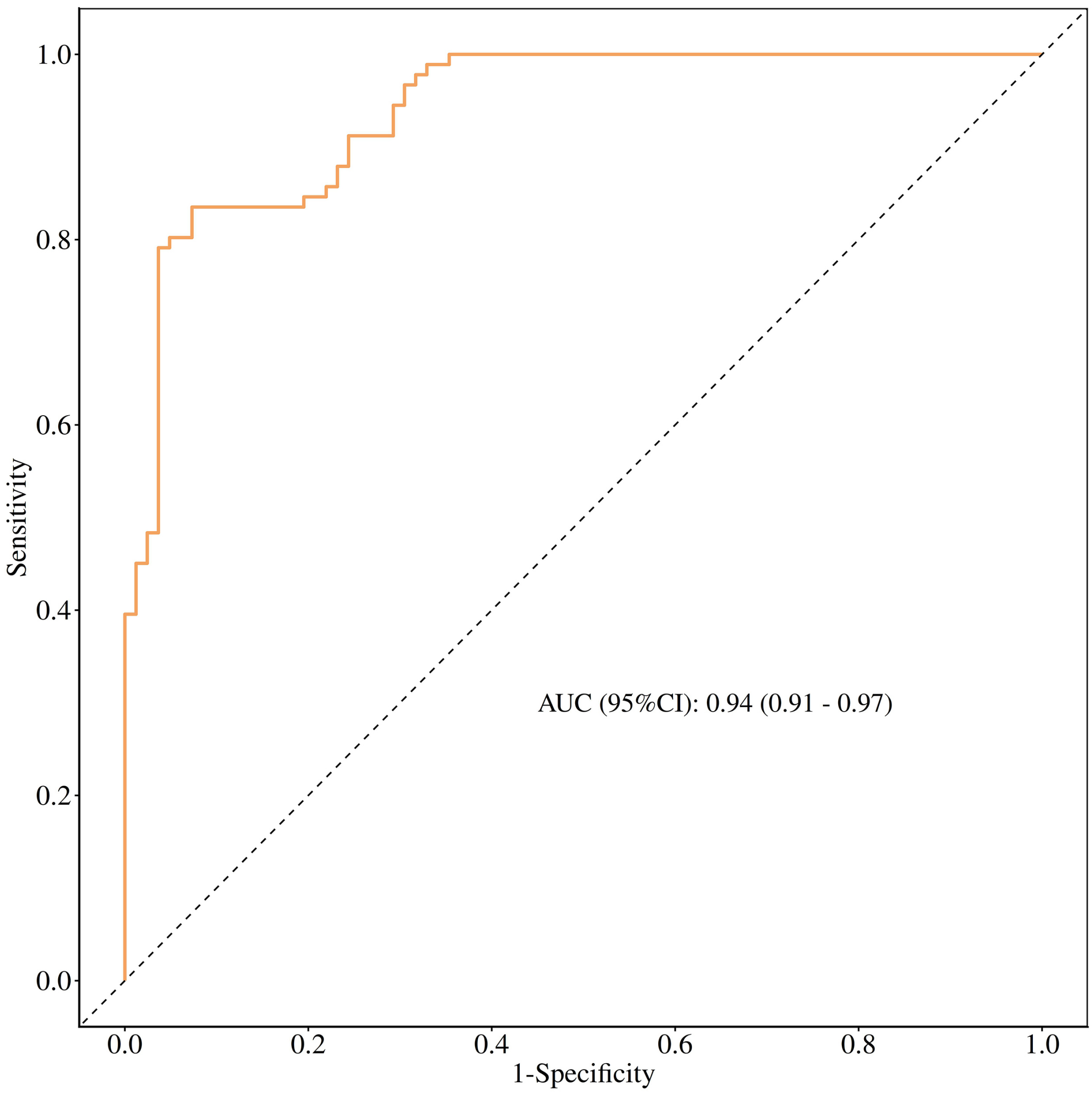

Fig. 2. ROC curve for risk factor identification. AUC, area under the curve; ROC, receiver operating characteristic.

into the persistent high pain group. Previous research has shown that negative emotions may intensify pain perception through central sensitization mechanisms and influence how individuals interpret pain [25]. Patients with higher anxiety levels are often more alert to postoperative discomfort and are more prone to catastrophic thinking, thereby amplifying the subjective pain experience; while depression may weaken the ability to actively cope and prolong the duration of perceived pain [26]. The above results suggest that preoperative psychological assessment should not be limited to routine screening, but should be integrated into comprehensive perioperative management.

Social support levels showed a protective effect in the multivariate model. Patients with higher social support scores were more likely to enter the pain relief trajectory category. Good family companionship, informational support, and practical care assistance all help alleviate postoperative anxiety and tension and improve adherence to analgesic treatment. For those with lower social support levels, supplementation can be achieved through enhanced communication between medical staff, improved discharge instructions, and follow-up management.

It is noteworthy that some patients maintained significant pain levels even 14 days post-surgery. This phenomenon was relatively high in this study. The reasons may be related to a combination of factors: firstly, patients with grade III–IV mixed hemorrhoids had more severe primary lesions and more pronounced local tissue inflammation; secondly, the presence of multiple ligation sites may prolong wound healing time; and thirdly, individual differences in pain sensitivity and the continued influence of psychological state cannot be ignored. Furthermore, changes in postoperative bowel habits, constipation, or wound friction may also delay the pain relief. However, these factors are difficult to fully quantify in retrospective studies and thus constitute inherent limitations in the explanatory scope of this study.

From a clinical perspective, the results of this study suggest that greater attention should be paid to individual differences in postoperative pain management. Relying solely on average pain scores is insufficient to identify persistently high-risk individuals. For patients with a large number of bandages or significant preoperative negative emotions, perioperative strategies for intensive analgesia and psychological intervention can be considered in advance. For patients with insufficient social support, extended nursing care and health education should be used to supplement support resources. Early identification of different recovery patterns may improve the targeted nature of postoperative management.

This study also has several limitations. First, it was a single-center retrospective design, with a relatively limited sample size, which may introduce selection bias. Second, the psychological and social support indicators were based on self-report scales, which may be influenced by subjective factors. Additionally, VAS scores were collected via face-to-face interviews during hospitalization and via telephone follow-up. Although standardized instructions were used for all assessments, the different modes of administration may have introduced measurement bias. In addition, postoperative analgesic regimens were individually adjusted according to patients' pain intensity, and detailed analgesic consumption was not systematically quantified; therefore, differences in analgesic management may have introduced residual confounding in the observed pain trajectories and their associated factors. Third, this study focused on exploring pain-development trajectories and assessed the discriminative ability of the multivariate model only using ROC curves, without performing calibration curve or decision curve analysis. Furthermore, the follow-up period was limited to 14 days post-surgery, failing to observe longer-term pain outcomes. Another issue requiring attention is that some patients still reported high pain scores two weeks post-surgery, which may be attributable to individual differences in wound healing, adherence to analgesia protocols, changes in bowel habits, and the duration of inflammation. Future research could further explore these factors by combining objective wound assessment indicators with inflammatory biomarkers.

Conclusions

In summary, patients with mixed hemorrhoids exhibit significant differences in their postoperative pain recovery trajectory after elastic band ligation. The number of ligations used, preoperative emotional state, and level of social support are closely associated with the pain development pattern. These factors may help identify patients at risk of unfavorable pain trajectories and inform individualized postoperative management.

Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

JP and XPW designed the research study. JP and GMX performed the research. CDJ analyzed the data. XPW and GMX drafted the article. All authors contributed to the critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was approved by the Ethics Committee of The People's Hospital of Tinghu District (approval number: 2025-SR-036), and all procedures followed the principles of the Declaration of Helsinki. As this was a retrospective observational study involving only previously collected clinical diagnoses and treatment data, no additional interventions were introduced, and no risks were posed to patients' diagnostic or therapeutic processes or privacy rights. Therefore, the requirement for written informed consent was waived with approval from the hospital ethics committee.

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Conflict of Interest

The authors declare no conflict of interest.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.62713/aic.4649.

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