ORIGINAL RESEARCH

Modified Frailty Index and Albumin-Fibrinogen Ratio Predicts Postoperative Seroma After Laparoscopic TAPP

Yang Zhou, Yongxiang Ge, Jian Liu, Weijian Shen, Hailiang Gu, Guochang Cheng

Department of Hernia and Pediatric Surgery, Taizhou People's Hospital, Taizhou Clinical Medical School of Nanjing Medical University, Taizhou City, Jiangsu Province, 225300, People's Republic of China

Correspondence: Guochang Cheng, Email chengguochang@hotmail.com

Background: Postoperative seroma is the most common minor complication after inguinal hernia repair surgery and can have negative consequences. The objective of this study was to identify potential risk factors for postoperative seroma.

Methods: This study consecutively included 354 elderly patients with inguinal hernia who underwent laparoscopic Transabdominal preperitoneal Patch Plasty (TAPP). Seroma diagnosis was conducted by the same experienced surgeon based on the physical examinations combined with ultrasound. Risk factors for seroma were identified through univariate analysis and subsequently included in the binary multivariate logistic regression model.

Results: A total of 40 patients experienced postoperative complications of seroma, with an incidence rate of 11.3% (40/354). The binary logistic regression analysis revealed that obesity (OR: 2.98, 95% CI: 1.20–7.41, P = 0.018), disease duration ≥ 4.5 years (OR: 4.88, 95% CI: 2.14–11.18, P < 0.001), albumin-fibrinogen ratio (AFR) level < 9.25 (OR: 6.13, 95% CI: 2.00–18.76, P = 0.001), and modified frailty index (mFI) score ≥ 0.225 (OR: 6.38, 95% CI: 2.69–15.10, P < 0.001) were four independent risk factors for postoperative seroma.

Conclusion: Obesity, prolonged disease duration, decreased AFR level, and increased mFI score independently predict postoperative seroma after laparoscopic TAPP.

Keywords: inguinal hernia, Transabdominal preperitoneal Patch Plasty, modified frailty index, albumin-fibrinogen ratio, risk factor

Introduction

Inguinal hernia is a very common surgical condition and over 20 million patients undergo inguinal hernia repair surgery worldwide every year.[1] The prevalence of inguinal hernia increases with age, and it is 8–10 times higher in men than women.[2,3] Because of the advantages of small wounds and allowing visual inspection of both inguinal regions, laparoscopic repair constitutes a large proportion of inguinal hernia surgeries.[4] Transabdominal preperitoneal Patch Plasty (TAPP) is a very commonly used surgical method for inguinal hernia repair.[5]

Seroma, defined as the localized accumulation of serous fluid within tissue, represents the most frequent minor complication following inguinal hernia repair surgery.[6] Due to the varying definitions and interpretations of seroma, the reported seroma incidence rates range widely from 0.5% to 78%, suggesting significant discrepancies among different studies.[7,8] Although seroma typically resolves within a few weeks, it can lead to various complications. Among these, infected seromas are particularly challenging and may necessitate mesh removal or result in hernia recurrence.[9,10] The occurrence of seroma can result in prolonged hospital stays, reduced patient comfort during treatment, hernia patch displacement and hernia recurrence.[1] Therefore, it is imperative to conduct extensive research on the factors contributing to the development of postoperative seroma. According to a recent study conducted by Atsushi et al,[4] it was found that two risk factors significantly contribute to the formation of postoperative seroma/hematoma: hernia size ≥ 3 cm and internal inguinal hernia. Despite extensive research on the subject, there is currently no consensus regarding the specific

risk factors associated with the development of postoperative seroma. In addition, most studies focus on the surgery associated factors as main reasons and the points towards systematic (eg, frailty) are quite limited. The objective of this study was to identify the potential risk factors for postoperative seroma formation following TAPP surgery.

Materials and Methods
Patients
This study consecutively included 354 elderly patients with inguinal hernia who underwent laparoscopic TAPP at Taizhou People's Hospital between 2020 and 2022. The inclusion criteria were: (1) elderly patients ≥ 65 years old; (2) with clinical manifestations, imaging, and intraoperative findings that met the diagnostic criteria for inguinal hernia; (3) undergoing laparoscopic TAPP without contraindications; (4) with no history of previous inguinal surgery, and (5) follow-up ≥ 3 months. The exclusion criteria were: (1) lack of clinical data or follow-up; (2) recurrent hernia; (3) with blood coagulation disorder, and (4) undergoing laparotomy or conversion to open repair. This study was approved by the ethics committee of our Hospital and enrolled patients were required to offer written consent.

Surgical Procedures
Preoperative prophylactic antibiotics were selectively administered based on specific conditions with high risk of infection (eg, combined with several underlying disease), rather than being routinely prescribed. All surgeries were performed by the same experience surgical team under general anesthesia. The intra-abdominal CO_2 pressure was maintained at 8–10 mmHg throughout the procedure. Following dissection, a pre-shaped lightweight polypropylene mesh (3D Max, Bard) was utilized to precisely fit the defect. The mesh was inserted through the 10 mm umbilical port and unrolled to cover the entire myopectineal orifice on the hernia side(s) without fixation. The peritoneal flap was closed utilizing a continuous suture pattern with 3–0 Vicryl sutures.

Data Collection
The data presented herein were obtained from the medical records of the subjects enrolled in this study: (1) Demographic data, including age, gender, body mass index (BMI), obesity, and smoking habits; (2) Disease and treatment-related data, including duration of disease, antithrombotic drug, history of abdominal surgery, sides, operation time, hernia aperture diameter, types of hernias, classification of hernias, emergency surgery, and mFI; (3) Preoperative laboratory data (obtained on the morning of the day prior to surgery), including hemoglobin, white blood cell (WBC), C-reactive protein (CRP), albumin, fibrinogen, neutrophil, lymphocyte, and platelet.

Observational Endpoints and Definitions
The primary endpoint of the current study was the occurrence of seroma formation within 3 months following TAPP surgery. Patients were routinely follow-up at postoperative 7 days, 1, and 3 months. Seroma diagnosis was conducted by the same experienced surgeon based on the physical examinations combined with ultrasound. A seroma is characterized as the accumulation of fluid beneath the skin without the presence of any solid component.[11]

Modified frailty index (mFI) was calculated based on the previous criteria, incorporating eleven components (dividing the number of positive items by 11).[12,13] The albumin-fibrinogen ratio (AFR) was determined by dividing the serum albumin level by the fibrinogen level. The neutrophil-lymphocyte ratio (NLR) and platelet-lymphocyte ratio (PLR) were calculated by dividing the levels of neutrophils and platelets, respectively, by the level of lymphocytes.

Statistical Analysis
The statistical analysis was conducted using SPSS 23.0 (SPSS Inc, IL, USA) and GraphPad Prism 9.0 (GraphPad Inc., CA, USA), respectively. The data are presented as means accompanied by their corresponding standard deviations (SD) and numbers expressed in percentages (n,%). Statistical analysis was conducted using Student t, Mann Whitney U, and Chi-square tests as appropriate. Additionally, a receiver operating characteristic (ROC) curve was constructed to evaluate the predictive and cut-off values of continuous variables. Binary logistic regression analyses were performed to identify

risk factors for postoperative seroma. A test for multicollinearity, which involved the use of the tolerance and Variance Inflation Factor (VIF), was performed to assess the presence of multicollinearity among the factors. Significance was set at a two-tailed P-value of < 0.05.

Results

Based on the predefined inclusion and exclusion criteria, a total of 354 elderly patients with inguinal hernia were ultimately enrolled in this study. The cohort had an average age of 76.2 years, with male patients accounting for 85.9% (304/354) of the sample. Within the first three months after surgery, a total of 40 patients experienced postoperative complications of seroma, with an incidence rate of 11.3% (40/354). Table 1 displays the demographic, disease-related, and treatment-related characteristics of patients with or without postoperative seroma. Patients who developed seroma exhibited a significantly higher rates of obesity (P = 0.003), a longer duration of disease (P = 0.013), and a larger hernia aperture diameter (P = 0.003) compared to those without seroma. Patients in the seroma group exhibited a higher incidence of bilateral hernias (P = 0.041) and correspondingly longer operative duration (P = 0.023). Moreover, patients with irreducible/incarcerated hernias (P = 0.043) or those undergoing emergency surgery (P = 0.018) appear to have a higher susceptibility to seroma formation.

The comparison of laboratory variables revealed no significant differences in hemoglobin, WBC, NLR, and PLR between patients with or without seroma (P > 0.05). Patients in the seroma group exhibited significantly lower levels of AFR (P < 0.001), higher levels of CRP (P = 0.040), and a greater mFI score (P < 0.001) compared to those in the non-seroma group.

Table 1 Variables Associated with Postoperative Seroma in Elderly Patients with Inguinal Hernia After TAPP

Variables	Postoperative Seroma		P-value
	Yes (n=40)	No (n=314)	
Age (year)	76.0±4.0	76.2±3.9	0.761
Gender, n (%)	–	–	0.754
Male	35(87.5)	269(85.7)	–
Female	5(12.5)	45(14.3)	–
BMI (kg/m^2)	22.5±2.9	21.9±2.4	0.133
Obesity, n (%)	14(35.0)	50(15.9)	0.003*
Smoking, n (%)	9(22.5)	54(17.2)	0.409
Duration of disease (year)	4.3±1.3	3.9±0.9	0.013*
Antithrombotic drug, n (%)	7(17.5)	47(15.0)	0.675
History of abdominal surgery	8(20.0)	44(14.0)	0.314
Sides, n (%)	–	–	0.041*
Unilateral	26(65.0)	249(79.3)	–
Bilateral	14(35.0)	65(20.7)	–
Operation time (min)	75.5±19.4	68.6±17.8	0.023*
Hernia aperture diameter (cm)	4.4±0.9	3.9±1.0	0.003*
Types of hernias, n (%)	–	–	0.760
Indirect hernia	30(75.0)	241(76.8)	–
Direct hernia	7(17.5)	58(18.5)	–
Femoral hernia	3(7.5)	15(4.8)	–
Classification of hernias, n (%)	–	–	0.043*
Reducible hernia	30(75.0)	273(86.9)	–
Irreducible/incarcerated hernia	10(25.0)	41(13.1)	–
Emergency surgery, n (%)	8(20.0)	26(8.3)	0.018*

Note: *P value<0.05 by Chi-square test, t-test or Mann Whitney U-test.
Abbreviations: TAPP, Transabdominal preperitoneal Patch Plasty; BMI, body mass index.
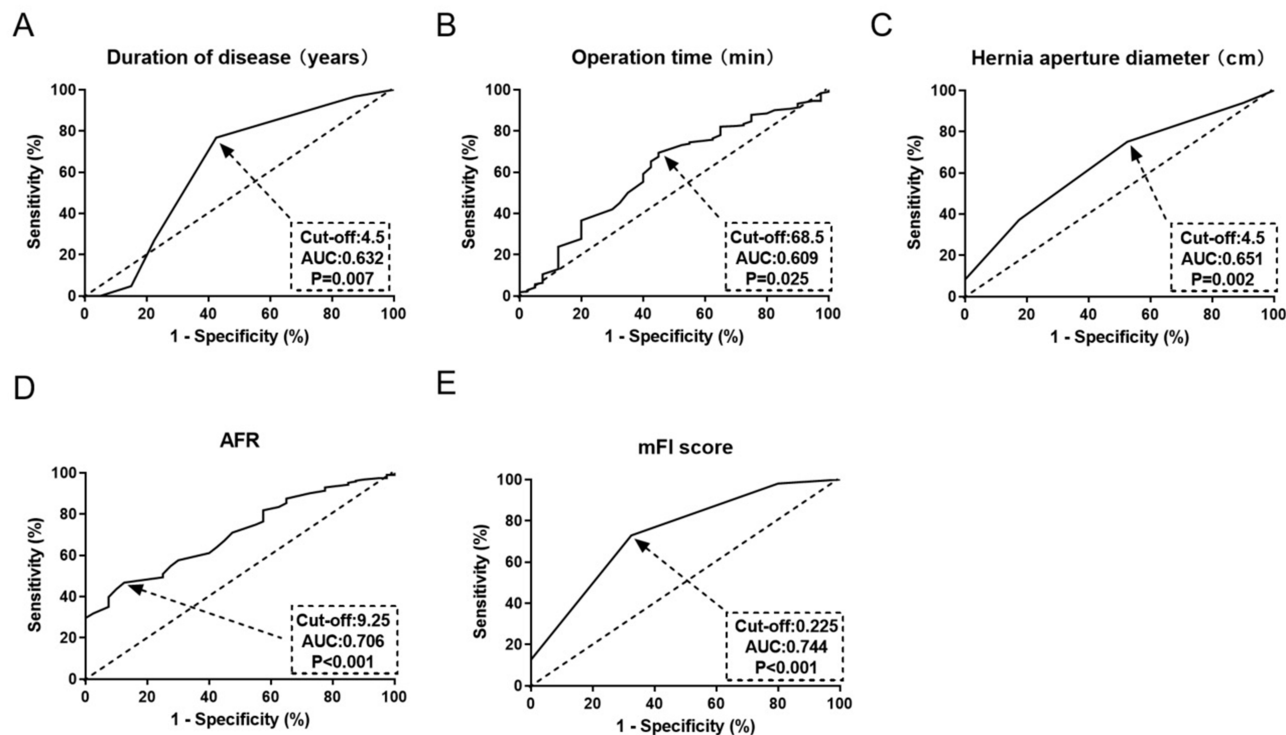
Table 2 Laboratory Variables Associated with Postoperative Seroma in Elderly Patients with Inguinal Hernia After TAPP

Variables	Postoperative Seroma		P-value
	Yes (n=40)	No (n=314)	
Hemoglobin (mg/dL)	12.3±1.7	12.6±1.5	0.242
White blood cell (×10^9/L)	7.3±1.7	7.0±1.7	0.294
C-reactive protein, n (%)	–	–	0.040*
≥8 mg/L	9(22.5)	35(11.1)	–
<8 mg/L	31(77.5)	279(88.9)	–
AFR	8.3±0.9	9.2±1.2	<0.001*
NLR	2.7±0.5	2.6±0.5	0.234
PLR	139.6±37.8	132.0±36.6	0.219
mFI score	0.26±0.06	0.20±0.06	<0.001*

Note: *P value<0.05 by Chi-square test, t-test or Mann Whitney U-test.
Abbreviations: TAPP, Transabdominal preperitoneal Patch Plasty; AFR, albumin-fibrinogen ratio; NLR, neutrophil-lymphocyte ratio; PLR, platelet-lymphocyte ratio; mFI, modified frailty index.

Subsequently, we conducted ROC curve analyses to determine the optimal predictive values and cut-off points for continuous variables (with a significance level of P < 0.05 as shown in Table 1 and Table 2). As illustrated in Figure 1, the duration of disease (cut-off value: 4.5 years, sensitivity: 76.75%, specificity: 57.50%, AUC: 0.632, P = 0.007), operation time (cut-off value: 68.5 min, sensitivity: 69.43%, specificity: 55.00%, AUC: 0.609, P = 0.025), hernia aperture diameter (cut-off value: 4.5 cm, sensitivity: 75.16%, specificity: 47.50%, AUC: 0.651, P = 0.002), AFR (cut-off value: 9.25, sensitivity: 46.82%, specificity: 87.50%, AUC: 0.706, P < 0.001), and mFI score (cut-off value: 0.225, sensitivity: 72.93%, specificity: 67.50%, AUC: 0.744, P < 0.001) were five predictive factors for the occurrence of postoperative seroma.

Figure 1 Predictive values of continuous variables for postoperative seroma in elderly patients with inguinal hernia after TAPP by ROC curve analyses. (**A**) Duration of disease; (**B**) Operative time; (**C**) Hernia aperture diameter; (**D**) AFR; and (**E**) mFI score.
Abbreviations: TAPP, Transabdominal preperitoneal Patch Plasty; ROC, receiver operating characteristic; AFR, albumin-fibrinogen ratio; mFI, modified frailty index; AUC, area under the curve.

Table 3 Binary Multivariate Logistic Regression Analysis of Postoperative Seroma in Elderly Patients with Inguinal Hernia After TAPP

Variables	Multicollinearity Test		Multivariate	
	Tolerance	VIF	OR (95% CI)	*P* value
Obesity (yes vs no)	0.954	1.048	2.98(1.20–7.41)	0.018*
Duration of disease (≥ 4.5 vs < 4.5)	0.957	1.045	4.88(2.14–11.18)	<0.001*
Sides (bilateral vs unilateral)	0.402	2.487	1.28(0.38–4.27)	0.686
Operation time (≥ 68.5 vs < 68.5)	0.383	2.610	2.11(0.67–6.58)	0.200
Hernia aperture diameter (≥ 4.5 vs < 4.5)	0.960	1.041	1.91(0.83–4.36)	0.127
Classification of hernias (irreducible/incarcerated vs reducible hernia)	0.365	2.741	2.77(0.49–15.60)	0.247
Emergency surgery (yes vs no)	0.363	2.759	1.64(0.24–11.20)	0.612
C-reactive protein (≥ 8 vs < 8)	0.961	1.040	2.21(0.74–6.65)	0.157
AFR (< 9.25 vs ≥ 9.25)	0.944	1.059	6.13(2.00–18.76)	0.001*
mFI score (≥ 0.225 vs < 0.225)	0.918	1.090	6.38(2.69–15.10)	<0.001*

Note: **P* value<0.05.
Abbreviations: TAPP, Transabdominal preperitoneal Patch Plasty; AFR, albumin-fibrinogen ratio; mFI, modified frailty index OR, odds ratio; CI, confidence interval.

Based on the optimal cut-off points, continuous variables were dichotomized into high (≥cut-off value) and low (< cut-off value) categories. As presented in Table 3, the multicollinearity analysis indicated no significant evidence of linearity between postoperative seroma and the potential risk factors. The binary logistic regression analysis revealed that obesity (OR: 2.98, 95% CI: 1.20–7.41, P = 0.018), disease duration ≥ 4.5 years (OR: 4.88, 95% CI: 2.14–11.18, P < 0.001), AFR level < 9.25 (OR: 6.13, 95% CI: 2.00–18.76, P = 0.001), and mFI score ≥ 0.225 (OR: 6.38, 95% CI: 2.69– 15.10, P < 0.001) were four independent risk factors for postoperative seroma.

Discussion

The exact cause of postoperative seroma remains incompletely understood. Given its adverse effects, investigating potential risk factors and implementing preventative measures is crucial for improving prognosis. The overall incidence of seroma in this study was 11.3%, as determined by physical examinations combined with ultrasound, which is consistent with the reported rate of 12.6% by Ruze et al[14] and lower than the rate of 19.2% reported by Morito et al.[4]

This study firstly highlighted obesity, disease duration ≥ 4.5 years, AFR level < 9.25, and mFI score ≥ 0.225 as four independent risk factors for postoperative seroma. Previous studies have reported a close relationship between the hernia aperture diameter and the formation of postoperative seroma.[14] The local tissue adhesion and increased surgical difficulty caused by large hernia aperture diameter are probably the main reasons for the increased risk of postoperative seroma formation. However, our results did not support hernia aperture diameter as an independent risk factor for postoperative seroma. We consider that different patient characteristics, and different surgical strategies (eg, patch types, fixation methods, etc.) were the main potential reasons for the different conclusions.

A previous study conducted by Tomita et al[15] has indicated that patients with an elevated BMI are at a higher risk of developing seroma compared to those with a normal BMI. Additionally, another study by Klink et al[16] has also revealed a strong correlation between higher BMI and increased formation of seroma. These findings are in line with our results, indicating that patients with obesity exhibit a disproportionately enlarged wound cavity, which subsequently facilitates the development of seroma.[16] Our research has also uncovered a strong correlation between the duration of the disease and the formation of seromas. We consider that long-term inguinal hernia, which contains a significant amount of abdominal contents within the hernia sac, is prone to inducing local inflammatory responses. This can lead to hyperplasia of postoperative scar tissue, obstruction of lymphatic reflux channels and an increased risk of postoperative seroma. This could potentially serve as an explanation for the independent association between the duration of disease and seroma risk.

AFR, which is calculated based on albumin and fibrinogen levels, serves as an optimal indicator for evaluating nutritional status, systemic inflammation, and coagulation function.[17] Moreover, it has been widely utilized as a prognostic factor in various diseases.[18,19] A decreased serum albumin is correlated with impaired tissue

regeneration[20] and elevated levels of proinflammatory mediators.[21] In addition, fibrinogen exerts potent effects on both acute and reparative inflammatory pathways that modulate the spectrum of tissue injury, remodeling, and repair.[22] A reduction in the albumin level or an increase in fibrinogen, or both, can lead to a decrease in the AFR. This may partially account for the strong correlation between the decreased AFR and postoperative seroma formation.

mFI, a widely used tool to assess the frailty status, has been widely used as prognostic factors in elderly patients.[23,24] A recent study conducted on patients who underwent total joint arthroplasty revealed that frailty was associated with an increased risk of postoperative complications, including hematoma/seroma formation,[25] which is consistent with our findings. Frailty is commonly associated with compromised immune function and reduced body resistance, rendering individuals more susceptible to infection and inflammation following surgery,[26] thereby elevating the risk of post-operative seroma formation. Furthermore, the presence of muscle atrophy and impaired function in frail patients can negatively impact lymphatic drainage and fluid metabolism,[27,28] potentially contributing to the development of post-operative seroma.

In conclusion, this study has underscored that obesity, prolonged disease duration, decreased AFR level, and increased mFI score are four independent risk factors for postoperative seroma in elderly patients with inguinal hernia after laparoscopic TAPP. This study has some limitations. The single centre single surgeon setting without an independent assessor of the clinical results parameters is a main weakness. Moreover, whether the improvements of some factors (eg, AFR) can reduce the incidence of seroma needs to be verified by further prospective studies.

Data Sharing Statement

Please contact the corresponding author for data requests.

Ethics Approval and Consent to Participate

This study was approved by the ethics committee of Taizhou People's Hospital, Taizhou Clinical Medical School of Nanjing Medical University. All methods were carried out in accordance with relevant guidelines by Declaration of Helsinki. Written Informed consent was obtained from all participants/patients.

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Disclosure

The authors report no conflicts of interest in this work.

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