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Frequency and Predictors of Postoperative Fluid Collections (POFC) in Patients Following Ventral Hernia Repair with Mesh Implants

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Abstract

Background: This study aimed to identify risk indicators for fluid accumulation after ventral hernia repair and to develop a prognostic model for postoperative fluid collections in the implantation area.

Methods and Results: A retrospective analysis was conducted on the medical records of 214 patients who underwent ventral hernia repair (VHR). Postoperative complications following surgical intervention were analyzed. In this study, cases of postoperative fluid collections (POFC) in the area of mesh implantation following VHR with synthetic mesh materials were analyzed. POFC was operationally defined as sterile, non-infected fluid accumulations detected in the postoperative period by ultrasound examination, characterized by the absence of clinical signs of inflammation, redness, fever, or infection.

The incidence of persistent POFC in the study cohort was 23(10.7%) out of 214 patients. A univariate analysis of the association between the presence of POFC and preoperative laboratory parameters showed statistically significant differences between the study groups for neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), prognostic nutritional index (PNI), and albumin level. The analysis of the association between postoperative Day 1 laboratory parameters and the development of POFC showed that among the analyzed laboratory parameters, a statistically significant difference between patients with and without POFC was identified for total protein level. On postoperative Day 5, statistically significant differences between patients with and without POFC were observed for hemoglobin and total protein levels, suggesting a potential role of protein metabolism and blood oxygen transport function in the pathogenesis of persistent fluid collection formation.

A multivariate statistical analysis using binary logistic regression identified significant predictors of POFC development in the postoperative period: hernia defect diameter (AOR=1.143; 95% CI: 1.042–1.254; P=0.005), NLR (AOR=1.596; 95% CI: 1.235–2.063; P<0.001), and the presence of ischemic heart disease (AOR=10.275; 95% CI: 2.801–37.675; P<0.001). The prognostic model demonstrated good discriminatory ability, with an AUC of 0.87 (95% CI: 0.775–0.966; P<0.001), sensitivity of 82.6%, and specificity of 81.7%.

Conclusion: The results obtained confirm a significant association between the anatomical characteristics of the hernia defect, the presence of cardiovascular pathology, the systemic inflammatory response, and the risk of persistent postoperative fluid accumulation. A nomogram based on the obtained logistic regression model was created, enabling the prediction of the likelihood of developing this complication. (**International Journal of Biomedicine. 2025;15(3):511-516.**)

Keywords: ventral hernia repair • post-operative fluid accumulation • prognostic model

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Abbreviations

IHD, ischemic heart disease; **NLR**, neutrophil-to-lymphocyte ratio; **PLR**, platelet-to-lymphocyte ratio; **PNI**, prognostic nutritional index, **POFC**, postoperative fluid collections; **VHR**, ventral hernia repair.

Introduction

Ventral hernia repair (VHR) is an integral part of abdominal surgery, aimed at restoring the anatomical integrity of the anterior abdominal wall, eliminating hernia defects, and preventing recurrences. However, despite advances in surgical techniques and the introduction of modern alloplastic materials, the incidence of postoperative complications remains significant, with no substantial downward trend.[1] Among these complications, a particular concern is the formation of postoperative fluid collections (POFC), which are pathological accumulations of non-infected lymphatic and serous fluid.[2] The development of POFC is associated with prolonged hospitalization, an increased rate of infectious complications, pain syndrome, and a higher risk of hernia recurrence and the need for reoperation.[3] Early stratification of patients based on the risk of complications opens opportunities to implement preventive measures and to individualize postoperative follow-up strategies.[4]

Despite several studies addressing risk factors for POFC following hernia repair, current data remain incomplete, and prognostic assessment criteria are not sufficiently standardized. Moreover, there is a notable lack of publications on this topic in domestic surgical literature.

This study aimed to identify risk indicators for fluid accumulation after ventral hernia repair and to develop a prognostic model for postoperative fluid collections in the implantation area.

Materials and Methods

A retrospective analysis was conducted on the medical records of patients who underwent VHR at the Department of Surgery of the E.M. Chuchkalov Ulyanovsk Regional Clinical Center for Specialized Medical Care (Ulyanovsk, Russia) between February 1, 2024, and May 1, 2025. Postoperative complications following surgical intervention were analyzed. A total of 214 patient records were reviewed according to a standardized, pre-developed protocol.

Surgical procedures were performed using an approach that varied depending on patient characteristics, hernia size and location, and individual anatomical features. Medical records and clinical data were analyzed according to the standardized study protocol. Patients who did not meet the inclusion criteria or had incomplete clinical data were excluded from the study. The primary indication for hernia repair was the presence of a ventral hernia. Cases requiring combined surgical procedures were excluded from this analysis.

Inclusion Criteria

•Patient age ≥ 18 years

•Elective ventral incisional hernia repair using a synthetic mesh implant

•Availability of complete clinical data in the medical records, including patient history, laboratory and instrumental investigation results, and detailed information on the postoperative course

•Laboratory tests performed preoperatively and on postoperative days 1 and 5

•Documented presence or absence of postoperative fluid characteristics during the early postoperative period

Exclusion Criteria

•Absence of key clinical or laboratory data required for objective statistical analysis

•Surgical procedures involving local tissue repair or performed as part of an emergency or combined operation that did not conform to the study protocol

•Presence of an active malignant neoplasm at the time of surgery

In this study, cases of POFC in the area of mesh implantation following VHR with synthetic mesh materials were analyzed. POFC was operationally defined as sterile, non-infected fluid accumulations detected in the postoperative period by ultrasound examination, characterized by the absence of clinical signs of inflammation, redness, fever, or infection. Regardless of their presumed origin (serous or lymphatic), these fluid collections were considered a single clinical category for statistical analysis.

Postoperative patient management followed a standardized protocol. Antibacterial therapy, including antibiotic prophylaxis, was administered in accordance with the recommendations of the Russian Association for Antimicrobial Therapy (CKAT).[5] Wound healing was monitored daily during dressing changes, with findings documented in the medical records. In cases of adverse wound healing, bacterial cultures were routinely obtained to assess microbial flora and antibiotic sensitivity.

Statistical analysis

All statistical analyses were performed using StatTech v. 4.8.2 (Stattech LLC, Russia). The distribution of continuous variables was assessed using the Shapiro–Wilk test ($n < 50$) or the Kolmogorov–Smirnov test ($n \geq 50$). Normally distributed variables were reported as mean ± standard deviation (SD). Non-normally distributed data were presented as median (Me) and interquartile ranges (IQR [Q1;Q3]). Categorical variables were described using absolute numbers and percentages. Between-group comparisons of normally distributed continuous variables were performed using Student's t-test. The Mann–Whitney U test was used for nonparametric comparisons. Group comparisons concerning categorical variables were performed using chi-square or Fisher's exact tests. A multiple logistic regression analysis was conducted to calculate the unadjusted and adjusted odds ratios (UOR and AOR) with 95% CI. Survival analysis was carried out using the Kaplan–Meier method, and differences between groups were evaluated with the log-rank test. Cox proportional hazards regression was used to assess the impact of independent predictors on recurrence risk over time. A *P*-value of less than 0.05 was considered statistically significant.

Results

The study included 63(29.4%) women and 151(70.6%) men. The incidence of persistent POFC in the study cohort was 23(10.7%) out of 214 patients. The main clinical, laboratory and surgical characteristics of the study population are presented in Tables 1 and 2.

Table 1.

Clinical characteristics of the study groups.

Indicator	Category	No POFC n=191	POFC n=23	*P*-value
Age, Me [IQR]		61.00 [47.00 – 67.50]	65.00 [53.50 – 71.50]	0.178
Gender, n (%)	Female	54 (28.3 %)	9 (39.1 %)	0.333
	Male	137 (71.7 %)	14 (60.9 %)	
Obesity, n (%)	No	113 (59.2 %)	11 (47.8 %)	0.372
	Yes	78 (40.8 %)	12 (52.2 %)	
Diabetes mellitus, n (%)	No	112 (58.6 %)	10 (43.5 %)	0.186
	Yes	79 (41.4 %)	13 (56.5 %)	
IHD, n (%)	No	116 (60.7 %)	5 (21.7 %)	< 0.001
	Yes	75 (39.3 %)	18 (78.3 %)	
CKD, n (%)	No	115 (60.2 %)	10 (43.5 %)	0.178
	Yes	76 (39.8 %)	13 (56.5 %)	

IHD, ischemic heart disease; CKD, chronic kidney disease.

Table 2.

Hospital and surgical parameters of the study groups.

Parameter	No POFC n=191	POFC n=23	*P*-value
Hospital stay, Me [IQR]	6.00 [4.00; 9.00]	16.00 [14.00; 20.00]	< 0.001
Operation time, Me [IQR]	45.00 [30.00; 62.50]	55.00 [42.50; 65.00]	0.061
Blood loss, Me [IQR]	15.00 [10.00; 30.00]	20.00 [10.00; 30.00]	0.254
Defect diameter, Me [IQR]	8.00 [5.00; 11.00]	11.00 [9.20; 15.00]	< 0.001

Based on the results of the statistical analysis, the presence of ischemic heart disease was found to have a significant impact on the development of POFC. In addition, we analyzed the surgical parameters of the patients. Based on that analysis, defect diameter was identified as an independent predictor of persistent POFC.

A univariate analysis of the association between the presence of POFC and preoperative laboratory parameters was also conducted. Statistically significant differences between the study groups were identified in the preoperative laboratory parameters for neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), prognostic nutritional index (PNI), and albumin level, suggesting a potential role of systemic inflammatory response and nutritional status in the development of persistent POFC (Table 3).

A univariate analysis of the association between postoperative Day 1 laboratory parameters and the development of POFC was performed (Table 4). Among the analyzed laboratory parameters, a statistically significant difference between patients with and without POFC was identified for total protein level, suggesting a potential influence of protein metabolism on the risk of persistent fluid collection formation. On postoperative Day 5, statistically significant differences between patients with and without POFC were observed for hemoglobin and total protein levels, suggesting a potential role of protein metabolism and blood oxygen transport function in the pathogenesis of persistent fluid collection formation (Table 5).

Table 3.

Preoperative laboratory parameters of the study groups.

Indicator	No POFC n=191	POFC n=23	*P*-value
Leukocytes, Me [IQR]	7.34 [6.08; 9.14]	7.64 [6.15; 8.96]	0.777
NLR, Me [IQR]	1.76 [1.27; 2.32]	3.15 [2.69; 4.21]	< 0.001
TLI, Me [IQR]	117.65 [96.96; 146.22]	113.48 [92.99; 157.70]	0.870
PNI, Me [IQR]	42.47 [40.33; 44.45]	41.21 [39.41; 41.71]	0.033
Hemoglobin, M ± SD	139.23 ± 20.16	147.74 ± 17.95	0.054
Total protein, Me [IQR]	68.28 [65.78;70.81]	68.60 [64.75;70.80]	0.896
Albumin, Me [IQR]	42.46 [40.32; 44.44]	41.20 [39.40; 41.70]	0.035

NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; PNI, prognostic nutritional index.

Table 4.

Laboratory parameters on postoperative Day 1.

Indicator	No POFC n=191	POFC n=23	*P*-value
leukocytes, Me [IQR]	8.61 [7.85; 10.37]	7.59 [6.98; 11.13]	0.339
NLR, Me [IQR]	3.90 [2.89; 5.55]	4.21 [2.91; 6.67]	0.415
TLI, Me [IQR]	149.46 [114.45; 195.27]	159.63 [137.62; 210.75]	0.870
PNI, Me [IQR]	38.55 [38.07; 39.09]	38.55 [38.07; 39.09]	0.403
Hemoglobin, Me [IQR]	134.60 [129.60;142.00]	132.80 [(127.40;138.70]	0.228
Total protein,Me [IQR]	63.80 [63.00;65.70]	62.84 [59.40;63.71]	0.002
Albumin, Me [IQR]	38.36 [37.88; 38.90]	38.36 [37.88; 38.90]	0.353

NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; PNI, prognostic nutritional index.

Table 5

Laboratory Parameters on Postoperative Day 5.

Indicator	No POFC n=191	POFC n=23	*P*-value
Leukocytes, Me [IQR]	26.40 [21.80; 31.80]	31.00 [20.20; 40.00]	0.419
NLR, Me [IQR]	2.56 [2.19; 3.31]	2.58 [2.21;3.84]	0.505
TLI, Me [IQR]	151.85 [129.68; 186.59]	140.97 [126.25; 172.64]	0.780
PNI, Me [IQR]	35.42 [33.49; 37.85]	35.48 [34.02; 37.85]	0.662
Hemoglobin, [IQR]	126.00 [116.00;139.00]	132.00 [127.00;143.00]	0.021
Total protein, Me [IQR]	61.64 [59.79;63.82]	60.20 [58.05;61.66]	0.016
Albumin, Me [IQR]	35.24 [33.32; 37.66]	35.30 [33.85; 37.66]	0.651

NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; PNI, prognostic nutritional index.

A multivariate statistical analysis using binary logistic regression identified significant predictors of POFC development in the postoperative period. The following variables were included as independent predictors in the model: hernia defect diameter (AOR=1.143; 95% CI: 1.042–1.254; *P*=0.005), NLR (AOR=1.596; 95% CI: 1.235–2.063; *P*<0.001), and the presence of ischemic heart disease (AOR=10.275; 95% CI: 2.801–37.675; *P*< 0.001) (Table 6). A prognostic model was developed to estimate the probability of detecting POFC based on these factors. Figure 1 presents the ROC curve demonstrating the performance of the prognostic model in identifying cases (hernia defect diameter, NLR, and the presence of ischemic heart disease) of persistent POFC in the implantation area. The area under the ROC curve (AUC) was 0.87 (95% CI: 0.775–0.966; *P*<0.001), and the model demonstrated statistical significance. The sensitivity and specificity of the model were 82.6% and 81.7%, respectively.

Table 6.

Predictors of POFC development in the postoperative period.

Predictor	Unadjusted		Adjusted	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
IHD	5.568 (1.984 – 15.643)	0.001	10.275 (2.801 – 37.675)	< 0.001
NLR	1.456 (1.186 – 1.786)	< 0.001	1.596 (1.235 – 2.063)	< 0.001
Hernia defect diameter	1.151 (1.061 – 1.250)	0.001	1.143 (1.042 – 1.254)	0.005

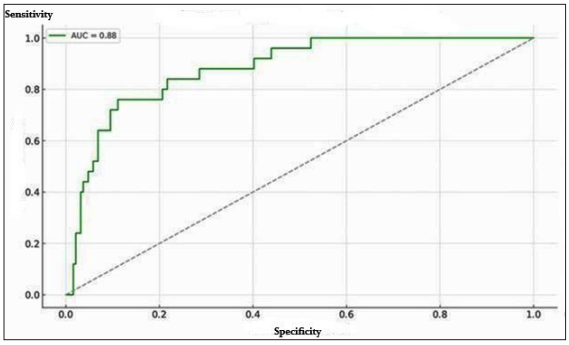

Figure 1. *ROC curve demonstrating the performance of the prognostic model in identifying cases (hernia defect diameter, NLR, and the presence of ischemic heart disease) of persistent POFC in the implantation area.*

Discussion

The formation of postoperative fluid collections, including seromas and lymphoceles, represents one of the most common complications following hernia repair with mesh implants. These pathological conditions arise from the combination of several pathogenic mechanisms: lymphatic capillary injury during tissue dissection, the creation of significant unfilled spaces ("dead space"), and an inflammatory response to the presence of a foreign implant. According to Lindmark et al,[6] the incidence of seromas following ventral hernia repair can reach up to 18.7%, particularly in laparoscopic procedures involving extensive tissue dissection.

Key pathophysiological mechanisms include increased vascular wall permeability, activation of inflammatory mediators, and limited natural drainage during the early postoperative period.[7] Several previously published studies have highlighted significant risk factors for postoperative fluid collections, including obesity, large operative volume, prolonged operative time, larger mesh placement area, the use of synthetic materials, and the presence of comorbid diabetes mellitus.[8] Notably, the study by Kapellas et al.[9] demonstrated that extensive tissue dissection and lateral mesh fixation significantly increase the risk of persistent fluid collection formation. Clinically, postoperative fluid collection is associated with prolonged hospitalization, increased postoperative pain, a higher risk of prosthetic infection, and the potential need for reoperation.[10] In some cases, persistent fluid collections may lead to late hernia recurrence and chronic inflammation in the implantation area.

In this study, the incidence of this postoperative complication following ventral hernia repair with mesh implants was 10.7%, which is comparable to the results of Howard et al.,[11] where the adjusted complication rate across hospitals was 6.2%.

Our statistical analysis revealed that the PNI, which reflects the patient's response to surgical intervention, significantly influences the development of postoperative fluid collections. Similar findings confirming the impact of PNI on

infectious complications in abdominal surgery patients were reported by Benjamin et al.[12]

Moreover, it is important to note that red blood cell count in the preoperative complete blood count, hemoglobin level on postoperative Day 5, and total protein levels in the biochemical analysis on postoperative Days 1 and 5 were also statistically significant factors associated with postoperative fluid collection development. This correlation is likely due to their close relationship with PNI as an indicator of the patient's overall condition. Similar results were reported by Sim et al., highlighting the association of these predictors with postoperative outcomes.[13]

Based on our analysis, the presence of ischemic heart disease, as a systemic vascular condition, was found to negatively affect microcirculation and tissue healing processes, thereby potentially increasing the risk of impaired lymphatic drainage and lymph accumulation in the postoperative area. These findings are consistent with those of Anastasopoulos et al.,[14] who highlighted the association between cardiovascular pathology and an increased risk of persistent fluid collections in patients undergoing abdominal wall surgery after organ transplantation.

The NLR, which reflects the balance between neutrophilic inflammation and lymphocytic regulation, is a recognized marker of systemic inflammatory response. In our study, elevated NLR was significantly associated with an increased likelihood of postoperative fluid collection in the implantation area. Similar associations have been reported by both domestic and international authors, demonstrating that elevated NLR values predict the development of postoperative complications, including postoperative fluid collections.[15]

We also identified an association between hernia defect diameter and the risk of postoperative fluid collections. Larger surgical fields may result in greater lymphatic vessel injury and impaired drainage.[16] This observation is supported by the findings of Veroux et al., which emphasized that the extent of anatomical dissection and surgical area correlates with the probability of lymphatic fluid accumulation.

In the present study, we developed a prognostic model to estimate the probability of postoperative fluid collections following ventral hernia repair. Multivariate analysis identified the presence of ischemic heart disease, elevated NLR, and increased hernia defect diameter as significant independent predictors of this complication. All three predictors demonstrated statistical significance in both unadjusted and adjusted models. The model exhibited high discriminatory power, with the determined cutoff probability threshold (0.143) providing an optimal balance of sensitivity (82.6%) and specificity (81.7%). This supports the potential application of the model as a preoperative risk stratification tool.

Thus, the results of our study confirm the importance of a comprehensive assessment of cardiovascular status, systemic inflammation, and morphometric characteristics of the hernia defect in predicting postoperative fluid collections. The use of this model may contribute to the individualization of surgical strategies and the implementation of preventive measures in patients at high risk of complications.

Conclusion

The incidence of postoperative fluid collections in patients undergoing ventral hernia repair with mesh implants was 10.7%. The results obtained confirm a significant association between the anatomical characteristics of the hernia defect, the presence of cardiovascular pathology, the systemic inflammatory response, and the risk of persistent postoperative fluid accumulation. A nomogram based on the obtained logistic regression model was created, enabling the prediction of the likelihood of developing this complication.

Ethical Considerations

The study protocol was reviewed and approved by the Ethics Committees at the Regional Oncology Dispensary and Ulyanovsk State University, Ulyanovsk, Russia.

Competing Interests

The authors declare that they have no competing interests.

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