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Predictors of peritoneal lavage use in pediatric open appendectomy: A retrospective study

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Abstract

Objective: This study aims to identify the clinical and diagnostic parameters influencing the decision to perform peritoneal lavage during pediatric open appendectomy.

Materials and methods: The files of patients who underwent open appendectomy due to acute appendicitis were retrospectively scanned. The patients were divided into two groups based on whether peritoneal lavage was performed. Age, gender, accompanying symptoms, physical examination findings, hemoglobin, leukocyte, C-reactive protein (CRP), abdominal ultrasonography (USG), abdominal tomography (CT) findings, intraoperative findings, and hospital stay duration of the groups were recorded.

Results: The mean age and hemoglobin values of the peritoneal lavage group were statistically significantly lower than those without lavage ($p<0.05$). Fever, vomiting, nausea, diarrhea, rebound, and CRP were higher in the lavage group ($p<0.05$). Leukocyte count and symptom onset time were statistically significantly lower in the no-lavage group ($p<0.05$). A statistically significant negative correlation existed between age, hemoglobin, CRP levels, and peritoneal lavage. There was a statistically significant and positive relationship with other parameters ($p<0.05$). According to the results of binary logistic analysis, CT and hemoglobin parameters were also substantial in multivariate analysis ($p<0.05$).

Conclusion: While many factors affect the decision to perform peritoneal lavage in univariate analysis, CT findings and hemoglobin levels are significant parameters in multivariate analysis.

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Introduction

Peritoneal lavage refers to the intraoperative practice of irrigating the peritoneal cavity, typically with saline or antiseptic solutions, to assist in clearing contaminants during abdominal surgery (1,2). In the context of appendicitis, this maneuver is often applied during surgery in cases with evident purulent material or perforation, rather than as a standard prophylactic intervention (3-8). Despite its frequent use in clinical practice, evidence remains inconclusive regarding its benefit in reducing postoperative complications such as intra-abdominal abscess or adhesions, particularly in pediatric populations (9-12). Many surgeons subscribe to the long-standing surgical notion that dilution resolves contamination; however, current evidence does not substantiate this belief (1). Although current moderate-quality evidence does not support the routine use of intraoperative peritoneal lavage in patients with appendicitis, many surgeons continue to perform this procedure as part of standard surgical practice (1,12,13). The benefits of saline-based intraoperative peritoneal lavage for patients with peritonitis remain uncertain (1,2). Peritoneal lavage with various liquids, with or without antibiotics, is frequently performed to prevent intra-abdominal abscess formation after appendectomy. However, studies show that peritoneal irrigation does not significantly affect intra-abdominal abscess formation after appendectomy (2). Robust scientific evidence indicates that saline-based intraoperative peritoneal lavage can extend operative time by an average of approximately 10 minutes, suggesting that this may have important clinical and logistical implications for surgical care (1,14).

This study aims to identify the factors influencing the decision to perform peritoneal lavage during open appendectomy in pediatric patients and to evaluate, through multivariate analysis, the impact of this intervention on relevant clinical and disease-related outcomes.

Materials and methods

We retrospectively reviewed medical records of pediatric patients (ages 0–18) who underwent open appendectomy for acute appendicitis with intraoperative confirmation of acute appendicitis at two tertiary care centers between 2016 and 2023. Patients were grouped based on whether peritoneal lavage was performed intraoperatively. Inclusion criteria were: age under 18 years, intraoperative confirmation of acute appendicitis, and availability of complete medical records. Exclusion criteria were: incomplete clinical data, history of previous abdominal surgery, concomitant intra-abdominal conditions requiring alternative surgical procedures, cases converted from laparoscopic to open appendectomy, and patients who underwent laparoscopic appendectomy.

The collected data included age, sex, clinical symptoms, physical examination findings, laboratory values (hemoglobin, leukocyte count, C-reactive protein), imaging results (ultrasonography, computed tomography), intraoperative findings, and length of hospital stay.

Statistical analysis

Frequency analysis was used to define nominal and ordinal data and mean, and standard deviation values were used to define measurement data. The Chi-Square Likelihood Ratio and Fischer's Exact tests were used to analyze ordinal and nominal data. Kolmogorov Smirnov Test was used to analyze the normality of measurement data. In the difference analysis of the measurement values, nonparametric tests were performed because the distributions did not comply with the normal distribution. Mann Whitney U Test was used in difference analysis between groups, and Spearman's rho correlation was used for correlation analyses. Binary logistic regression analysis was performed to identify independent predictors of performing peritoneal lavage. Variables with a p-value < 0.10 in the univariate analyses were entered into the multivariate model. In our logistic model dependent variable selected as peritoneal lavage (1=peritoneal lavage, 0= non-peritoneal lavage) and the independent variables included as age, fever, vomiting, nausea, diarrhea, rebound, leukocyte count, hemoglobin level, symptom duration, CRP level, CT findings, USG findings, presence of purulent material, omentectomy, and hospitalization duration. Results were expressed as odds ratios (OR) with 95% confidence intervals (CI). During model fitting, the variables “Purulent” and “Omentectomy” demonstrated complete separation (i.e., no events in one comparison group), which resulted in unstable parameter estimates and inflated standard errors. These variables were retained in the table for transparency, but their OR values should be interpreted with caution. Model fit was assessed using the –2 Log Likelihood, Cox & Snell R^2, and Nagelkerke R^2 values. All analyses were conducted using SPSS version 17.0 for Windows (IBM Corp., Armonk, NY, USA), with a significance level set at $p<0.05$.

Ethical approval

An ethical compliance certificate was received from Yozgat Bozok University Non-Interventional Clinical Research Ethics Committee, dated 08/05/2024, with decision number 2024-GOKAEK-243_2024.05.08_48.

Results

A total of 129 pediatric patients who underwent appendectomy were included in the study; after 102 patients were excluded according to the exclusion criteria; of these, 60 (46.5%) underwent peritoneal lavage and 69 (53.5%) did not. The overall mean age was 11.85±3.56 years, with the lavage group being significantly younger than the non-lavage group (10.67±4.03 vs. 12.86±2.76 years; p=0.002). Females accounted for 51.7% of the lavage group and 37.7% of the non-lavage group (p=0.078) (Table 1).

The mean hemoglobin level in the peritoneal lavage group was 11.55±1.66 g/dL, which was significantly lower than that of the non-lavage group (12.57±1.69 g/dL; p<0.05). Fever, vomiting, nausea, diarrhea, rebound, and CRP elevation were higher in the lavage group, and the differences between the groups were significant (p<0.05). Leukocyte levels and time to onset of symptoms were statistically significantly lower in the no-lavage group. (p<0.05) (Table 1). Purulent fluid was seen only in the lavage group (p<0.05). The duration of hospital stay was also statistically significantly higher in the peritoneal lavage group (p<0.05) (Table 2). In correlation analysis, age, hemoglobin, and CRP levels were inversely associated with peritoneal lavage, while all other factors showed a significant positive correlation (p<0.05).

The correlation analysis indicates that there is no multicollinearity present in the model, as the variance inflation factor (VIF) scores for all predictors are below the threshold of 5, suggesting that the predictors are not highly correlated with each other. The correlation matrix can be seen in Figure 1.

There was a statistically significant and positive relationship with other parameters (p<0.05) (Table 3). Among the parameters that had a significant relationship with peritoneal washing in univariate analysis, only abdominal tomography and hemoglobin parameters were also substantial in multivariate analysis (p<0.05). The logistic regression table also included the variables "Purulent" and "Omentectomy," which showed complete separation and produced unstable parameter estimates due to the absence of cases in one group. Therefore, their reported OR values should be interpreted with caution. Cox & Snell and Nagelkerke's R2 values showed that the model had high explanatory power. Therefore, when all parameters related to the patients were considered, CT results and hemoglobin levels were significant in deciding on peritoneal irrigation (Table 4).

Discussion

The primary objective of this study was to perform a multivariate analysis of the factors influencing the surgeon's decision to perform peritoneal lavage during pediatric appendectomy. Our analysis demonstrated that hemoglobin level and abdominal CT findings were independent predictors, thereby achieving the primary endpoint. Specifically, the presence of purulent fluid and preoperative indicators such as low hemoglobin and abnormal CT results were strongly associated with the decision to perform lavage. While lower hemoglobin levels were significantly more common in the lavage group, there is no universally accepted cut-off value for this parameter, and it should be interpreted within the broader clinical and intraoperative context. Importantly, this study was not designed to assess the efficacy of lavage in preventing postoperative complications, as no follow-up outcome data were collected; therefore, these results primarily reflect surgical practice patterns rather than interventional outcomes. Although peritoneal lavage did not influence postoperative infection rates in our cohort, it was associated with longer hospitalization, which may have economic and logistical implications in pediatric surgical care. This finding highlights the importance of weighing potential benefits against the added resource utilization when deciding to perform lavage.

Although the principle that dilution resolves contamination has been long accepted in surgical practice, current evidence does not substantiate this belief, particularly in the context of appendicitis. Furthermore, there is no substantial evidence supporting the effectiveness of peritoneal lavage in reducing postoperative intra-abdominal abscess incidence in pediatric patients (1,13).

Importantly, this study does not aim to evaluate the efficacy of lavage in preventing postoperative complications, as no follow-up data on infection or other outcomes were collected. These findings reflect surgical practice patterns more than interventional outcomes. Interpretation should be limited to the predictors of intraoperative decisions. This study has several limitations. First, the retrospective design restricts causal inferences. Second, the absence of postoperative follow-up data, including rates of surgical site infections or intra-abdominal abscesses, limits our ability to assess the clinical impact of lavage. Third, reliance on operative notes and incomplete records may introduce bias in how intraoperative findings were interpreted. Lastly, the study lacks external validation and should be interpreted as hypothesis-generating.

Table 1: Baseline characteristics and difference results between patient groups

	Peritoneal lavage		p-value
	Yes (n=60; 46.5%)	No (n=69; 53.5%)	
Gender, n (%)			
Female	31 (51.7)	26 (37.7)	0.078[a]
Male	29 (48.3)	43 (62.3)	
Age, mean ± SD	10.67±4.03	12.86±2.76	0.002[b]
Fever, n (%)	34 (56.7)	11 (15.9)	0.000[a]
Vomiting, n (%)	27 (45.0)	8 (11.6)	0.000[a]
Nausea, n (%)	12 (20.0)	5 (7.2)	0.030[a]
Hematuria, n (%)	6 (10.0)	5 (7.2)	0.403[a]
Leukocytosuria, n (%)	9 (15.0)	5 (7.2)	0.130[a]
Diarrhea, n (%)	16 (26.7)	4 (5.8)	0.001[a]
Rebound, n (%)	55 (91.7)	54 (78.3)	0.030[a]
Distention, n (%)	10 (16.7)	20 (29.0)	0.074[a]
Leukocyte, mean ± SD	17208.33±4783.70	12744.93±2871.80	0.000[b]
Hemoglobin, mean ± SD	11.55±1.66	12.57±1.69	0.000[b]
Symptom duration, mean ± SD	4.05±2.28	1.62±0.57	0.000[b]
CRP, n (%)			
High	56 (93.3)	52 (75.4)	0.005[a]
Low	4 (6.7)	17 (24.6)	
CT, n (%)			
None	50 (83.3)	67 (97.1)	
Acute appendicitis	3 (5.0)	2 (2.9)	0.008[c]
Perforation	5 (8.3)	-	
Normal	2 (3.3)	-	
USG, n (%)			
None	11 (18.3)	23 (33.3)	
Acute appendicitis	17 (28.3)	31 (44.9)	
Perforation	15 (25.0)	2 (2.9)	0.001[c]
Normal	7 (11.7)	5 (7.2)	
Liquid	3 (5.0)	3 (4.3)	
Mesenteric lymphadenitis	7 (11.7)	5 (7.2)	
Incision type, n (%)			
Transverse	47 (78.3)	69 (100.0)	0.000[a]
Paramedian	13 (21.7)	-	
Omentectomy, n (%)	18 (30.0)	-	0.000[a]

a. Fischer's Exact Test, b. Mann Whitney U Test, c. Chi-Square Likelihood Ratio, SD: Standard Deviation.

Table 2: Purulent and hospitalization duration differences between patient groups

	Peritoneal lavage		p-value
	Yes (n=60; 46.5%)	No (n=69; 53.5%)	
Purulent, n (%)	37 (61.7)	-	0.000[a]
Hospitalization duration, mean±SD	6.33±3.23	2.14±0.71	0.000[b]

a. Fischer's Exact Test, b. Mann Whitney U Test, SD: Standard Deviation, N/A: Not Applicable.

In their study, Kotan et al (15) evaluated cleaning with dry compresses, peritoneal lavage methods with physiological saline or Ringer's lactate, and Povidone Iodine in the surgical treatment of intra-abdominal infections on a total of 113 cases and reported that dry cleaning gave the best results. The same study reported that the length of hospital stay was higher in the peritoneal irrigation groups. In their research, Uğur et al (16) investigated the effectiveness of peritoneal lavage in gastric perforations on 40 rats and reported that it caused more adhesion than wiping with moist compresses. On the other hand, Gammeri et al (2) reported in their meta-analysis that the contribution of peritoneal lavage performed to prevent postoperative intra-abdominal abscess formation after appendectomy to intra-abdominal abscess formation in patients was not statistically significant. High-quality evidence indicates that saline-based intraoperative peritoneal lavage can prolong operative time, potentially leading to notable clinical and logistical consequences in surgical practice (1,14).

Perovic (17) reported that complications were more common in children who underwent drainage after appendectomy. In our study, the fact that no postoperative infection was observed in any of the patients indicates that peritoneal washing for infection after appendectomy is an unnecessary invasive procedure, which aligns with the literature.

In our opinion, apart from its use in different areas, although there are not enough studies showing its benefits after appendectomy and no guide or directive in practice, it is possible to attribute this high use of peritoneal irrigation to two possibilities. The first one is that the physician uses it for self-assurance due to the lack of sufficient tests or knowledge of accompanying diseases in emergency interventions, and the second possibility is that it may be a practice behavior that has become routine for some surgeons. Both reasons make peritoneal irrigation reasonable for preventing intra-abdominal infection and adhesion development after appendectomy. However, both clinical studies and meta-analysis results, as well as the similarity

Table 3: Spearman's rho correlation analysis results between peritoneal lavage and significant factors

Peritoneal lavage	r	p-value
Age	-0.272**	0.002
Fever	0.426**	0.000
Vomiting	0.375**	0.000
Nausea	0.188*	0.033
Diarrhea	0.288**	0.001
Rebound	0.185*	0.036
Leukocyte	0.492**	0.000
Hemoglobin	-0.315**	0.000
Symptom duration day	0.659**	0.000
CRP	-0.243**	0.006
CT	0.242**	0.006
USG	0.260**	0.003
Omentectomy	0.432**	0.000
Purulent	0.680**	0.000
Hospital duration day	0.753**	0.000

*p<0.05, **p<0.01

Table 4. Binary logistic regression analysis results between peritoneal lavage and significant factors

	B	S.E.	Wald	p-value	OR
Age	-0.144	0.120	1.433	0.231	1.155
Fever	0.500	0.813	0.378	0.538	0.607
Vomiting	0.384	0.911	0.178	0.673	0.681
Nausea	0.278	1.338	0.043	0.836	0.758
Diarrhea	-1.912	1.742	1.204	0.273	6.764
Rebound	1.088	1.179	0.852	0.356	0.337
Leukocyte	0.000	0.000	0.213	0.644	1.000
Hemoglobin	-0.723	0.302	5.727	0.017*	2.060
Symptom duration day	1.124	0.637	3.110	0.078	0.325
CRP	0.489	0.797	0.376	0.540	0.613
CT	3.491	1.703	4,201	0.040*	0.030
USG	0.155	0.214	0.526	0.468	0.856
Purulent	18.225	6867.904	0.000	0.998	0.000
Omentectomy	-5.296	25286.281	0.000	>0.05	199.501
Hospital duration day	0.955	0.532	3.217	0.073	0.385
Constant	1.779	3.985	0.199	0.655	0.169
-2 Log Likelihood Ratio: 63.761; Cox & Snell R Square: 0.588; Nagelkerke R Square: 0.786					

*p<0.05

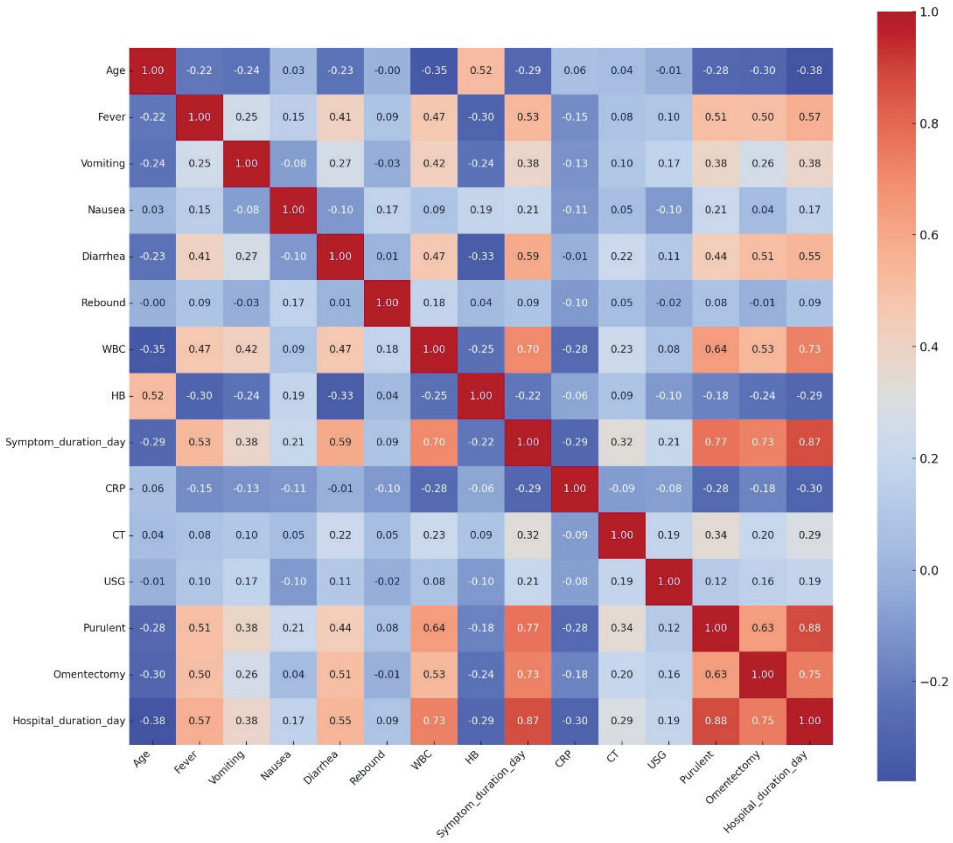

Figure 1. Correlation matrix

of the rates of patients who underwent and did not undergo peritoneal irrigation in retrospective studies, as in our research, reveal that peritoneal irrigation is not necessary after appendectomy to prevent intra-abdominal infection and adhesion.

Another finding that supports this argument is the univariate and multivariate analysis results. In univariate analysis, all parameters necessary for appendectomy appear to affect peritoneal lavage. However, the negative correlation coefficients of many parameters suggest that peritoneal lavage is generally performed if the patient's condition is poor. From this perspective, the surgeon's anxiety affects peritoneal lavage more. The fact that only hemoglobin and CT values of all these variables were significant in the multivariate analysis results shows that the univariate parameters were evaluated incorrectly. In other words, peritoneal lavage is performed during appendectomy in patients with only one or a few clinical values considered poor. However, studies and results show that peritoneal lavage does not significantly affect intra-abdominal infection after appendectomy.

Limitations

Limited results were obtained because the number of patients in this study was small, and it was designed retrospectively. Apart from these two limitations, the fact that no abdominal infection was observed in the postoperative period in either group limits the ability to make analyses that reveal the factors affecting disease development. However, this limitation is also seen in other studies in the literature, and the retrospective nature of our research was decisive at this point. Again, since the study is retrospective, postoperative pain, infection management, and longitudinal follow-up data are not regular in patients; this situation was also seen in our research as one of the general limitations of retrospective studies.

Conclusions

This retrospective study suggests that peritoneal lavage during pediatric open appendectomy is influenced by clinical and intraoperative factors, especially low hemoglobin levels and abnormal CT findings. However, in the absence of postoperative follow-up data, no conclusions can be drawn about the effectiveness of lavage in preventing complications. The findings reflect surgical decision-making patterns rather than the outcomes of those decisions. Future prospective studies with standardized protocols and outcome monitoring are needed to determine whether peritoneal lavage has any impact on clinical recovery.

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Contributions

Research concept and design: SUT, HI

Data analysis and interpretation: SUT, HI

Collection and/or assembly of data: SUT, HI, AS

Writing the article: SUT, HI

Critical revision of the article: SUT, HI, AS

Final approval of the article: SUT, HI, AS

All authors read and approved the final version of the manuscript.

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