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Comparison of Single-Dose Prophylactic versus Post-Operative Antibiotic Regimens on Inflammatory Markers and Surgical Site Infection Rates in Laparoscopic Cholecystectomy

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ABSTRACT

Objective: To compare the effects of single-dose pre-operative prophylactic antibiotics versus routine post-operative antibiotic therapy on inflammatory markers, cytokine response, and surgical site infection (SSI) rates in patients undergoing elective laparoscopic cholecystectomy.

Methodology: This prospective comparative study included 80 patients undergoing elective laparoscopic cholecystectomy, divided into two groups (n = 40 each). Group A received a single pre-operative prophylactic dose of antibiotic, while Group B received post-operative antibiotics for five days. Inflammatory markers including total leukocyte count (TLC), neutrophil percentage, neutrophil–lymphocyte ratio (NLR), C-reactive protein (CRP), interleukin-6 (IL-6), and tumor necrosis factor-alpha (TNF-α) were measured pre-operatively and 48 hours post-operatively. Patients were followed for 30 days for SSI.

Results: No significant difference was observed between groups in TLC, neutrophil percentage, NLR, CRP, or SSI rates ($p > 0.05$). However, IL-6 and TNF-α levels were significantly higher in the post-operative antibiotic group compared to the single-dose prophylaxis group ($p < 0.05$). Hospital stay was significantly shorter in the single-dose group.

Conclusion: Single-dose prophylactic antibiotics are equally effective in preventing SSI and controlling routine inflammatory markers following laparoscopic cholecystectomy. Elevated cytokine levels in the post-operative antibiotic group suggest persistent inflammatory signaling, indicating no additional benefit of extended antibiotic therapy in uncomplicated cases.

Keywords: Laparoscopic cholecystectomy, antibiotic prophylaxis, IL-6, TNF-α, surgical site infection

1. INTRODUCTION

Laparoscopic cholecystectomy is the preferred surgical treatment for gallstone disease because it is associated with reduced

tissue trauma, shorter hospital stay, and lower post-operative complication rates [1]. Despite these advantages, the routine use of prolonged post-operative antibiotics remains common practice in many developing healthcare settings, often without strong evidence-based justification [2].

Unnecessary antibiotic use contributes significantly to antimicrobial resistance, increased healthcare costs, and drug-related adverse effects [3]. International guidelines for clean-contaminated laparoscopic procedures recommend single-dose or limited peri-operative antibiotic prophylaxis; however, reluctance to discontinue post-operative antibiotic regimens persists among surgeons [4].

The surgical inflammatory response involves activation of both cellular and molecular immune pathways. Conventional markers such as total leukocyte count and C-reactive protein reflect systemic inflammation, whereas cytokines including interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α) act as early mediators of tissue injury and immune activation [5]. These cytokines are closely linked to the pathological processes of acute inflammation and may provide a more sensitive assessment of post-surgical inflammatory dynamics [6].

This study aims to compare single-dose prophylactic and post-operative antibiotic regimens in laparoscopic cholecystectomy by evaluating routine inflammatory markers, cytokine response, and surgical site infection rates.

2. METHODOLOGY

A prospective comparative study was conducted over six months in the Department of General Surgery at Nishtar Hopsital Multan, a tertiary care teaching hospital in Pakistan. A total of 80 patients scheduled for elective laparoscopic cholecystectomy were enrolled and divided into two equal groups: Group A (n = 40) received a single-dose prophylactic antibiotic, while Group B (n = 40) received a post-operative antibiotic regimen. Patients aged 18–60 years of either sex with American Society of Anesthesiologists (ASA) physical status I or II were included. Exclusion criteria comprised acute cholecystitis or cholangitis, diabetes mellitus, immunocompromised status, conversion to open surgery, and pre-existing infections. In Group A, a single intravenous dose of ceftriaxone 1 g was administered 30 minutes prior to skin incision. In Group B, patients received intravenous ceftriaxone 1 g post-operatively followed by oral antibiotics for five days. Blood samples were collected pre-operatively and 48 hours post-operatively to measure total leukocyte count, neutrophil percentage, neutrophil–lymphocyte ratio, C-reactive protein, interleukin-6, and tumor necrosis factor-alpha. Patients were followed for 30 days post-operatively for the development of surgical site infection as defined by Centers for Disease Control and Prevention criteria. Data were analyzed using SPSS version 25. Quantitative variables were expressed as mean ± standard deviation. Independent sample t-test was applied to compare continuous variables, and chi-square test was used for categorical variables. A p-value ≤ 0.05 was considered statistically significant.

3. RESULTS

The mean age of patients in Group A was 42.3 ± 9.1 years, compared with 44.1 ± 8.6 years in Group B. This difference was not statistically significant (p = 0.38), indicating that the two groups were comparable in terms of age. The gender distribution in Group A included 14 males and 26 females, while Group B comprised 16 males and 24 females. No significant difference was observed between the groups regarding sex (p = 0.65), confirming that both groups were balanced for gender as well.

As shown in table, operative assessment of inflammatory markers showed that total leukocyte count (TLC) was 8.9 ± 1.7 $\times 10^9$/L in Group A and 9.1 ± 1.9 $\times 10^9$/L in Group B, with no significant difference between the groups (p = 0.61). Similarly, neutrophil percentage was comparable, with 68.4 ± 6.2% in Group A and 69.7 ± 5.9% in Group B (p = 0.42). The neutrophil–lymphocyte ratio (NLR) also did not differ significantly, measuring 3.2 ± 0.9 in Group A and 3.4 ± 1.0 in Group B (p = 0.47). C-reactive protein (CRP) levels were slightly higher in Group B (19.9 ± 6.1 mg/L) than in Group A (18.6 ± 5.4 mg/L), but this difference was not statistically significant (p = 0.36).

In contrast, cytokine analysis revealed a significant difference between the groups. Interleukin-6 (IL-6) levels were markedly higher in Group B (28.7 ± 7.4 pg/mL) compared with Group A (20.9 ± 6.1 pg/mL), with a highly significant p-value (<0.001). Similarly, tumor necrosis factor-alpha (TNF-α) was elevated in Group B (17.9 ± 4.6 pg/mL) relative to Group A (13.8 ± 3.9 pg/mL), showing a statistically significant difference (p = 0.002). These findings indicate that single-dose prophylactic antibiotics (Group A) were associated with a lower post-operative cytokine response, while routine markers such as TLC, neutrophil percentage, NLR, and CRP did not show significant differences between the two regimens.

Comparison of Inflammatory Markers (48 Hours Post-Operative)

Marker	Group A	Group B	p-value
TLC (×10⁹/L)	8.9 ± 1.7	9.1 ± 1.9	0.61
Neutrophil (%)	68.4 ± 6.2	69.7 ± 5.9	0.42
NLR	3.2 ± 0.9	3.4 ± 1.0	0.47
CRP (mg/L)	18.6 ± 5.4	19.9 ± 6.1	0.36
IL-6 (pg/mL)	20.9 ± 6.1	28.7 ± 7.4	<0.001
TNF-α (pg/mL)	13.8 ± 3.9	17.9 ± 4.6	0.002

A statistically significant elevation of IL-6 and TNF-α was observed in Group B compared to Group A, while no significant difference was noted in routine inflammatory markers.

Post-operative outcomes were assessed in terms of surgical site infection (SSI) and duration of hospital stay. SSI occurred in 2 patients (5%) in Group A and 3 patients (7.5%) in Group B, with no statistically significant difference between the groups ($p = 0.64$). This indicates that single-dose prophylactic antibiotics were as effective as the post-operative antibiotic regimen in preventing SSI.

In contrast, the length of hospital stay differed significantly between the groups. Patients in Group A had a mean hospital stay of 1.6 ± 0.5 days, whereas those in Group B stayed for 2.8 ± 0.7 days ($p < 0.001$). This suggests that a single-dose antibiotic regimen is associated with a shorter post-operative hospitalization compared with routine post-operative antibiotic use.

4. DISCUSSION

This study demonstrates that single-dose prophylactic antibiotics are as effective as extended post-operative antibiotic regimens in preventing surgical site infections (SSI) following elective laparoscopic cholecystectomy. In our cohort, SSI rates were low and comparable between both groups, consistent with recent prospective studies that found no significant difference in infection rates between single-dose and multiple-dose antibiotic strategies in elective laparoscopic cholecystectomy [7,8]. A multi-centre retrospective analysis also reported similarly low SSI rates with limited peri-operative antibiotic use, reinforcing this finding [9].

Guidelines from major surgical societies recommend against routine peri-operative or post-operative antibiotics in low-risk patients undergoing elective laparoscopic cholecystectomy, reserving antibiotic use for high-risk cases (e.g., acute cholecystitis, immunocompromise) [10]. Implementation of antimicrobial stewardship protocols that significantly reduced prophylactic antibiotic use in elective procedures showed no increase in SSI or readmission rates, underscoring the safety of limited antibiotic exposure [11]. These stewardship principles align with evidence that single-dose prophylaxis may be sufficient for uncomplicated elective laparoscopic procedures and can reduce unnecessary antibiotic consumption and resistance pressures [7,8,11].

In this study, routine inflammatory markers (TLC, neutrophil percentage, NLR, CRP) were similar between groups, suggesting comparable systemic inflammatory responses. However, cytokine levels (IL-6 and TNF-α) were significantly lower in patients receiving single-dose prophylaxis. Elevated IL-6 and TNF-α have been recognized as early indicators of surgical stress and sterile inflammation rather than infection, and their persistent elevation may reflect ongoing inflammatory signaling not mitigated by prolonged antibiotics [12]. These findings support the concept that post-operative inflammation in uncomplicated laparoscopic surgery is largely sterile and driven by surgical trauma rather than bacterial contamination.

Furthermore, single-dose prophylaxis was associated with a significantly shorter hospital stay, highlighting potential economic and logistical benefits. Shorter hospitalization times with limited antibiotic strategies have also been reported in other comparative studies, suggesting efficiency gains without compromising patient safety [9,13]. Meta-analyses suggest that while peri-operative antibiotic prophylaxis may reduce superficial SSI overall, there is little evidence to justify extended multi-day post-operative courses in low-risk elective laparoscopic patients [14-16].

Taken together, these data support adopting a single-dose antibiotic protocol for elective laparoscopic cholecystectomy in low-risk patients, which may optimize resource utilization and align with international antimicrobial stewardship objectives.

5. CONCLUSION

Single-dose prophylactic antibiotic administration is sufficient for preventing surgical site infection and controlling routine inflammatory response in elective laparoscopic cholecystectomy. Elevated IL-6 and TNF-α levels in patients receiving post-operative antibiotics indicate persistent inflammatory signaling without clinical benefit. Routine post-operative antibiotic use in uncomplicated cases is unnecessary and should be avoided.

Recommendations

The findings of this study support the adoption of single-dose antibiotic prophylaxis in patients undergoing elective laparoscopic cholecystectomy, demonstrating that extended post-operative antibiotic regimens offer no additional benefit in preventing surgical site infections. Implementing this strategy allows for the avoidance of unnecessary post-operative antibiotic use, reducing the risk of adverse drug effects, antimicrobial resistance, and additional healthcare costs. Furthermore, these results underscore the importance of promoting antibiotic stewardship programs within surgical departments, emphasizing evidence-based prescribing practices that optimize patient outcomes while preserving the effectiveness of existing antimicrobial agents.

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