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The Effectiveness of Topical Cefuroxime Powder in Preventing Surgical Site Infection after Elective Paraumbilical Hernia Repair using Polypropylene Mesh

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ABSTRACT

Background: Paraumbilical hernia repair using polypropylene mesh is a widely accepted surgical approach due to its reduced recurrence rates compared with primary suture repair. However, surgical site infection remains a significant postoperative complication, particularly in patients with comorbidities such as diabetes, obesity, and smoking history. Topical application of cefuroxime powder has been proposed as an adjunctive preventive measure to lower infection risk. **Objective:** To determine the effectiveness of topical cefuroxime powder in preventing surgical site infection after elective paraumbilical hernia repair using polypropylene mesh as compared to no antibiotic use. **Study Design:** Randomized controlled trial. **Duration and Place of Study:** This study was conducted from May 2024 to October 2024 at the Department of General Surgery, Khyber Teaching Hospital, Peshawar. **Methodology:** A total of 386 patients aged 30–60 years undergoing elective paraumbilical hernia repair with mesh were randomized into two groups of 193 each. Group A received 750 mg topical cefuroxime powder applied over the mesh before closure, while Group B underwent standard repair without topical antibiotic. Postoperative follow-up was performed up to three months. Surgical site infection was diagnosed using Centers for Disease Control and Prevention criteria. **Results:** Surgical site infection occurred in 6 (3.1%) patients in Group A compared with 20 (10.4%) in Group B (p=0.004). Stratified analysis showed higher infection rates among overweight, diabetic, hypertensive, and smoking patients, with significant reduction in Group A across most subgroups. **Conclusion:** Topical cefuroxime powder significantly decreases surgical site infections in paraumbilical hernia repair with polypropylene mesh and offers a simple, effective preventive strategy.

INTRODUCTION

The utilization of polypropylene mesh in elective paraumbilical hernia reconstruction has become a widely recognized operative technique because it decreases the probability of recurrence compared to primary suture closure.[1] A paraumbilical hernia, which manifests as a fascial defect adjacent to the umbilicus, usually develops due to elevated intra-abdominal pressure, adiposity, gestation, or chronic cough.[2] The polypropylene mesh is manufactured and provides mechanical support to the damaged abdominal wall and minimizes tensile stress along the suture line.[3] Also, it incorporates itself with adjacent tissue and forges a strong fibrous capsule that provides fixation stability for several years.[4] Application of elective intervention has advantages such that the patient is optimized in controlled perioperative environment for better preparation and postoperative recovery. However, in spite of all these advantages which are associated with using it, it is never completely free from risks as one among most dreaded complications continues to be surgical site infection, continues to be a formidable clinical problem both from operating surgeon's perspective and patient perspective.[5]

Postoperative surgical site infection following elective paraumbilical hernia reconstruction is a foreseeable postoperative complication that results in increased patient morbidity, prolonged hospitalization, and increased therapeutic expense.[5] With implanted prosthetic material such as polypropylene mesh, it provides opportunity for microbial growth in terms of a foreign substrate in the operating field.[6] The odds of such infection could also increase with patient-related comorbid conditions such as diabetes mellitus, obesity, tobacco usage, and malnutrition and with intraoperative conditions such as prolonged operative time or inadequate aseptic measures.[7] Such infectious process not only

impeded wound healing process but also could necessitate prosthesis removal and accordingly increase hernia recurrence likelihood. To mitigate this risk, patients are usually administered prophylactic antimicrobial therapy and meticulous asepsis is maintained.

The topical administration of cefuroxime powder at the operative site has emerged as an effective adjunctive measure that may aid in preventing surgical site infection after paraumbilical hernia reconstruction.[8] Cefuroxime, a second-generation cephalosporin, demonstrates broad-spectrum efficacy against prevalent cutaneous and soft tissue pathogens such as Staphylococcus and Streptococcus.[9] When this powder is applied directly to the surgical field, it achieves very high local drug concentrations, which are not attainable through enteral or parenteral administration, while simultaneously minimizing systemic adverse effects.[10] In this manner, the antimicrobial powder reduces the likelihood of microbial adherence to the prosthetic mesh and adjacent tissues, thereby lowering the infection risk.[11] Multiple clinical investigations have demonstrated that topical antimicrobial application safeguards the wound from contamination and reduces postoperative infection incidence, while exerting no detrimental impact on wound healing or tissue incorporation with the mesh.

In a observational study, Zhuo et al. reported that the frequency of surgical site infection was 9.8% in patients who did not receive antibiotics, compared to 2.8% in those administered cefuroxime following elective hernia repair with mesh.[12]

There is high occurrence of paraumbilical hernia repair surgeries in Peshawar due to the prevalence of obesity, multiparity, and strenuous occupation. Surgical site infection continues to be frequent postoperative finding with consequences for local resources and delayed hospitalization. Despite universal use of systematic antibiotic prophylaxis, appreciable levels of infections continue to exist and are more frequent in mesh-assisted repairs. There is little evidence regarding the use of topical cefuroxime powder as additional preventive agent in this regional context. Accordingly, evaluation of its efficacy in Peshawar would assist in developing locally generalizable data, enhancing surgical outcomes, and curtailing healthcare costs related to postoperative infections.

METHODOLOGY

This randomized controlled trial was undertaken in the Department of General Surgery at Khyber Teaching Hospital, Peshawar, between May 2024 and October 2024. Prior to patient enrolment, approval was obtained from the hospital's ethics review committee (No. 218/DME/KMC, dated 13/04/2023). The sample size was calculated using the World Health Organization calculator, with a 95% confidence interval, 80% statistical power, and previously documented rates of surgical site infection of 9.8% in the absence of antibiotics and 2.8% following antibiotic use.[12] The final sample comprised 386 participants, equally divided into two groups of 193. Recruitment was carried out through consecutive sampling, followed by blocked randomization to allocate participants into study and control groups. Participants were eligible if they were between 30 and 60 years of age, of either sex, scheduled for paraumbilical hernia repair with mesh insertion, and tested negative to a cefuroxime intradermal sensitivity test (0.5 ml). Exclusion applied to patients with a prior history of abdominal surgery, those receiving systemic steroids, immunocompromised individuals, patients with active systemic infection, and those who had used antibiotics within the previous 48 hours. Written informed consent was obtained from all participants after the purpose, procedure, and follow-up plan were explained in detail.

Demographic characteristics were recorded. Medical history was taken to determine comorbidities such as hypertension and diabetes, and baseline investigations were performed to ensure anesthesia fitness. All participants underwent standard surgical preparation involving shaving of the abdominal wall and cleansing with povidone-iodine. Mesh repair was performed using a tension-free technique under general anesthesia by consultant surgeons with at least five years of post-fellowship experience. In the intervention group A, cefuroxime 750 mg powder was placed directly over the polypropylene mesh before skin closure. In the control group B, no topical antibiotic was applied. Postoperative care consisted of intravenous fluids, systemic antibiotics, analgesics, proton pump inhibitors, and antipyretics, followed by oral medication and multivitamins on discharge. Patients were evaluated daily during hospital stay, at suture removal on the twelfth postoperative day, and subsequently at one, two, and three months. Follow-up assessments were carried out by residents blinded to group allocation. Surgical site infection was identified based on Centers for Disease Control and Prevention criteria, requiring redness or swelling visible to the naked eye, systemic manifestations such as fever, malaise, or lethargy, and discharge of pus from the wound confirmed by positive bacterial culture within ninety days of surgery. A patient was classified as having mesh infection if all these criteria were met. Treatment was considered effective if no infection was detected during the three-month follow-up period.

Statistical analysis was performed using SPSS version 22. Normality of continuous data was assessed with the Shapiro–Wilk test. Quantitative variables were presented as mean ± standard deviation or median with interquartile range, depending on data distribution. Categorical variables were summarized as frequencies and percentages. Group comparisons for infection rates were conducted using the chi-square test, with significance set at $p \leq 0.05$. Stratification by age, sex, smoking, hypertension, diabetes, and overweight status was followed by post-stratification chi-square or Fisher's exact test as appropriate.

RESULTS

Patient demographics showed comparable baseline characteristics between groups, with mean ages of 45.15 ± 7.35 years versus 43.83 ± 7.44 years, mean weights of 72.34 ± 13.87 kg versus 73.05 ± 13.42 kg, mean heights of 160.80 ± 8.01 cm versus 162.03 ± 9.08 cm, and BMI values of 27.86 ± 4.11 kg/m^2 versus 27.76 ± 4.10 kg/m^2 for Groups A and B respectively. The mean duration of hernia was 19.85 ± 9.86 months in Group A and 16.85 ± 9.34

months in Group B. Gender distribution showed a predominance of females in both groups, with 165 (85.5%) females and 28 (14.5%) males in Group A compared to 144 (74.6%) females and 49 (25.4%) males in Group B. Rural residence was noted in 92 (47.7%) patients in Group A and 93 (48.2%) in Group B, while urban residence was observed in 101 (52.3%) and 100 (51.8%) patients respectively. Comorbidities included hypertension in 22 (11.4%) patients in Group A versus 8 (4.1%) in Group B, diabetes in 9 (4.7%) versus 16 (8.3%) patients, overweight status in 105 (54.4%) versus 108 (56.0%) patients, and smoking history in 15 (7.8%) versus 26 (13.5%) patients for Groups A and B respectively (as shown in Table 1).

Table 1

Patient Demographics in Both Groups

Variables	Topical Cefuroxime Powder n=193 Mean ± SD	No Topical Antibiotic n=193 Mean ± SD
Age (years)	45.15 ± 7.35	43.83 ± 7.44
Weight (kg)	72.34 ± 13.87	73.05 ± 13.42
Height (cm)	160.80 ± 8.01	162.03 ± 9.08
BMI (Kg/m²)	27.86 ± 4.11	27.76 ± 4.10
Duration (months)	19.85 ± 9.86	16.85 ± 9.34
Gender	**n (%)**	**n (%)**
Male	28 (14.5%)	49 (25.4%)
Female	165 (85.5%)	144 (74.6%)
Residence		
Rural	92 (47.7%)	93 (48.2%)
Urban	101 (52.3%)	100 (51.8%)
Hypertension		
Yes	22 (11.4%)	8 (4.1%)
No	171 (88.6%)	185 (95.9%)
Diabetes		
Yes	9 (4.7%)	16 (8.3%)
No	184 (95.3%)	177 (91.7%)
Overweight		
Yes	105 (54.4%)	108 (56.0%)
No	88 (45.6%)	85 (44.0%)
Smoking		
Yes	15 (7.8%)	26 (13.5%)
No	178 (92.2%)	167 (86.5%)

The primary outcome analysis demonstrated a statistically significant reduction in surgical site infections with topical cefuroxime powder, occurring in only 6 (3.1%) patients in Group A compared to 20 (10.4%) patients in Group B (p=0.004). Consequently, 187 (96.9%) patients in Group A remained infection-free compared to 173 (89.6%) in Group B (as shown in Table 2).

Table 2

Comparison of Surgical Site Infection between the Two Groups (n=386)

Surgical Site Infection	Group A n=193 n (%)	Group B n=193 n (%)	P value
Yes	6 (3.1%)	20 (10.4%)	
No	187 (96.9%)	173 (89.6%)	0.004
Total	193 (100%)	193 (100%)	

Stratified analysis by demographic variables revealed several important associations with surgical site infection rates. Age stratification showed that among patients ≤45 years, infections occurred in 2 (1.8%) patients in Group A versus 14 (11.9%) in Group B (p=0.005), while in patients >45 years, infections were observed in 4 (4.8%) versus 6 (8.0%) patients respectively (p=0.424). Gender analysis demonstrated that among males, surgical site infections developed in 2 (7.1%) patients in Group A compared to 14 (28.6%) in Group B (p=0.023), whereas among females, infections occurred in 4 (2.4%) versus 6 (4.2%) patients respectively (p=0.362). Hypertension status showed infections in 4 (18.2%) hypertensive patients in Group A versus 4 (50.0%) in Group B (p=0.153), and in 2 (1.2%) non-hypertensive patients in Group A versus 16 (8.6%) in Group B (p<0.001). Residence analysis revealed that among rural patients, infections occurred in 6 (6.5%) in Group A versus 10 (10.8%) in Group B (p=0.325), while no infections (0.0%) were observed among urban patients in Group A compared to 10 (10.0%) in Group B (p<0.001). Diabetes stratification showed a notably high infection rate of 6 (66.7%) among diabetic patients in Group A versus 4 (25.0%) in Group B (p=0.037), while no infections (0.0%) occurred among non-diabetic patients in Group A compared to 16 (9.0%) in Group B (p<0.001). Overweight patients showed infections in 6 (5.7%) in Group A versus 20 (18.5%) in Group B (p=0.007), while no infections occurred in non-overweight patients in either group (0.0% for both groups, p=1.000). Among smokers, infections developed in 2 (13.3%) patients in Group A versus 14 (53.8%) in Group B (p=0.017), whereas among non-smokers, infections occurred in 4 (2.2%) versus 6 (3.6%) patients respectively (p=0.516) (as shown in Table 3).

Table 3

Association of Surgical Site Infection with Demographic Variables

Demographics variables		Group	Surgical Site Infection		P-value
			Yes (n, %)	No (n, %)	
Age (years)	≤45	A	2 (1.8%)	107 (98.2%)	0.005*
		B	14 (11.9%)	104 (88.1%)	
	>45	A	4 (4.8%)	80 (95.2%)	0.424*
		B	6 (8.0%)	69 (92.0%)	
Gender	Male	A	2 (7.1%)	26 (92.9%)	0.023*
		B	14 (28.6%)	35 (71.4%)	
	Female	A	4 (2.4%)	161 (97.6%)	0.362*
		B	6 (4.2%)	138 (95.8%)	
Hypertension	Yes	A	4 (18.2%)	18 (81.8%)	0.153*
		B	4 (50.0%)	4 (50.0%)	
	No	A	2 (1.2%)	169 (98.8%)	<0.001*
		B	16 (8.6%)	169 (91.4%)	
Residence	Rural	A	6 (6.5%)	86 (93.5%)	0.325
		B	10 (10.8%)	83 (89.2%)	
	Urban	A	0 (0.0%)	101 (100.0%)	<0.001*
		B	10 (10.0%)	90 (90.0%)	
Diabetes	Yes	A	6 (66.7%)	3 (33.3%)	0.037*
		B	4 (25.0%)	12 (75.0%)	
	No	A	0 (0.0%)	184 (100.0%)	<0.001*
		B	16 (9.0%)	161 (91.0%)	
Overweight	Yes	A	6 (5.7%)	99 (94.3%)	0.007
		B	20 (18.5%)	88 (81.5%)	
	No	A	0 (0.0%)	88 (100.0%)	1.000*
		B	0 (0.0%)	85 (100.0%)	
Smoking	Yes	A	2 (13.3%)	13 (86.7%)	0.017*
		B	14 (53.8%)	12 (46.2%)	
	No	A	4 (2.2%)	174 (97.8%)	0.516*
		B	6 (3.6%)	161 (96.4%)	

*Fisher's Exact Test

DISCUSSION

This study demonstrates the significant prophylactic

efficacy of topical cefuroxime powder in reducing surgical site infections following elective paraumbilical hernia repair with polypropylene mesh, with infection rates decreasing from 10.4% in the control group to 3.1% in the treatment group. The substantial reduction in surgical site infections can be attributed to cefuroxime's broad-spectrum antimicrobial activity against both gram-positive and gram-negative bacteria commonly implicated in surgical wound infections, including Staphylococcus aureus, Streptococcus species, and Escherichia coli. The direct application of antibiotic powder to the surgical site achieves high local tissue concentrations that exceed the minimum inhibitory concentrations required for bacterial eradication, while minimizing systemic exposure and associated side effects. The stratified analysis reveals several clinically relevant patterns that align with established risk factors for surgical site infections, with the pronounced gender difference particularly notable as males in the control group showed significantly higher infection rates (28.6% versus 7.1% with cefuroxime), likely reflecting hormonal influences on immune function and wound healing processes where testosterone may impair immune responses compared to estrogen's protective effects on tissue repair.

The observed 67% reduction in surgical site infections with topical cefuroxime powder (3.1% vs 10.4%) aligns with several contemporary studies demonstrating the efficacy of topical antibiotic prophylaxis in hernia surgery. Al-Sa'adi et al. [13] reported remarkably similar findings in umbilical hernia repair, showing that combined topical and systemic antibiotic therapy achieved significantly lower infection rates compared to systemic therapy alone, with their meropenem group achieving the lowest infection rate of 0.9%. This corroborates our findings that direct topical application provides superior local antimicrobial coverage. Similarly, Bakhtiar et al. [14] demonstrated a significant reduction in SSI rates from 18.1% to 7.2% using single-dose prophylactic antibiotics in mesh inguinal hernia repair, though their overall infection rates were higher than our study, possibly due to differences in surgical technique and patient populations. The meta-analysis by Wijono et al. [15] encompassing 3,297 patients across 24 RCTs supports our results, showing prophylactic antibiotics reduced SSI from 7.88% to 4.5%, providing robust evidence for antibiotic prophylaxis in hernia surgery. Our baseline infection rate of 10.4% in the control group is consistent with rates reported by Khan et al. [16] who observed 10.4% SSI in their control group undergoing mesh inguinal hernia repair without prophylaxis. However, this rate is notably higher than the <2% baseline rates mentioned by Kulacoglu [17] for clean hernia surgeries, suggesting that paraumbilical hernias may carry inherently higher infection risks due to the umbilical region's bacterial colonization and potential contamination. The significant gender difference observed in our study, with males showing dramatically higher infection rates (28.6% vs 7.1%), finds partial support in Yatimparvar et al. [18] who noted that topical vancomycin was particularly beneficial in female craniotomy patients (0% vs 12.5% infection rate), though their overall study showed different gender distribution patterns.

The paradoxically high infection rate among diabetic patients receiving cefuroxime (66.7%) in our study contrasts sharply with the general protective effects observed in other patient subgroups and warrants careful consideration. While Borade et al. [19] identified obesity as a risk factor for SSI, none of the reviewed studies specifically addressed diabetes as a confounding factor for topical antibiotic efficacy. This suggests that hyperglycemia may compromise not only systemic immune function but also local tissue response to topical antibiotics, potentially through impaired drug penetration and altered local pH conditions that affect antibiotic activity. The complete absence of infections in non-diabetic patients receiving cefuroxime in our study demonstrates optimal drug efficacy in metabolically stable patients, supporting the mechanistic rationale for topical antibiotic use. The effectiveness of cefuroxime specifically is well-supported by Sastry et al. [20] who reviewed its role in surgical prophylaxis, noting significant SSI reduction from 9.4% to 2.8% in hernia repair, though this study utilized systemic rather than topical administration. Our results with topical cefuroxime appear superior to the systemic approach described by Masood et al. [21] who found no significant difference between single-dose prophylaxis and routine antibiotic therapy in inguinal hernia repair, achieving infection rates of 13.3% and 10% respectively. The superior efficacy of our topical approach likely reflects the achievement of higher local tissue concentrations while avoiding systemic side effects, as emphasized by Kulacoglu [22] who advocated for topical gentamicin in umbilical hernia repair due to the inherently non-sterile nature of the umbilical area.

The present study has several limitations that should be acknowledged when interpreting the results. This was a single-center study conducted at one institution, which may limit the generalizability of findings to different healthcare settings with varying surgical techniques, patient populations, and infection control practices. The study design did not allow for blinding of surgeons to the treatment allocation, which could potentially introduce bias in wound assessment and postoperative care decisions. The relatively short follow-up period may have missed delayed infections or long-term complications associated with topical antibiotic use. Additionally, the study did not evaluate potential adverse effects of topical cefuroxime, such as local allergic reactions or contribution to antibiotic resistance patterns. The sample size, while adequate for detecting the primary outcome difference, may have been insufficient to fully explore interactions between treatment effects and patient comorbidities, particularly the unexpected finding among diabetic patients.

CONCLUSION

Our study has concluded that topical cefuroxime powder application significantly reduces surgical site infections following elective paraumbilical hernia repair with polypropylene mesh compared to standard care without topical antibiotics. The intervention demonstrated particular efficacy in non-diabetic patients, urban residents, and non-hypertensive individuals, while showing notable benefits across most demographic subgroups.

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