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Optimizing Antibiotic Prophylaxis Strategies: Single Dose Versus Multiple Dose Antibiotics in Clean Surgical Procedures

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KEYWORDS

Surgical site infection.
Antibiotic prophylaxis.
Meshplasty.

ABSTRACT:

Background: Surgical site infections (SSI) remain an important cause of morbidity after clean surgical procedures. Prolonged use of antibiotic prophylaxis is common practice, despite guideline recommendations supporting single-dose regimens. This study aimed to compare the efficacy of single-dose versus multiple-dose antibiotic prophylaxis in clean surgical procedures.

Methods: A prospective comparative study was conducted at a tertiary care hospital over 10 months. Fifty patients undergoing elective ventral hernia repair were randomized into two groups: Group A (25 patients, onlay meshplasty with multiple-dose prophylaxis) and Group B (25 patients, sublay meshplasty with single-dose prophylaxis). Data on surgical duration, surgical site infections, postoperative complications (seroma, wound infection, flap necrosis), hospital stay, and cost-effectiveness were analyzed using appropriate statistical tests.

Results: The mean duration of surgery was similar in both groups (101.6 ± 37.8 min vs. 97.2 ± 30.3 min; p=0.652). Overall complication rates were significantly higher in the onlay group (36.0%) compared to the sublay group (8.0%; p=0.014). SSI occurred in 16.0% of onlay versus 4.0% of sublay patients (p=0.157). Seroma formation (20.0% vs. 4.0%) and flap necrosis (16.0% vs. 0%) were more common in the onlay group, with flap necrosis showing statistical significance (p=0.037). The average hospital stay was longer in the onlay group (4.88 ± 1.30 days) compared to the sublay group (3.84 ± 0.99 days; p=0.003). Cost-effectiveness favored single-dose prophylaxis due to reduced antibiotic usage and shorter hospitalization.

Conclusion: Single-dose antibiotic prophylaxis is effective, safe, and cost-efficient for clean surgical procedures. When combined with sublay meshplasty, it provides superior outcomes compared to onlay repair with multiple-dose prophylaxis. Adoption of single-dose strategies in line with global guidelines can reduce unnecessary antibiotic exposure and associated complications while maintaining patient safety.

INTRODUCTION

The use of antibiotic prophylaxis in surgical practice has been one of the most important advances in reducing postoperative infectious complications. Clean surgical procedures, defined as those in which no inflammation is encountered, the respiratory, alimentary, or genitourinary tracts are not entered, and there is no break in aseptic technique, traditionally carry a low risk of surgical site infections (SSI). Despite this, postoperative infections in clean surgeries can result in significant morbidity, prolonged hospital stay, increased healthcare costs, and in rare cases, mortality. Thus, antibiotic prophylaxis is often employed to further reduce these risks.[1]

Historically, the practice of antibiotic prophylaxis evolved from the mid-20th century when penicillin was first introduced in surgical wards. Early studies demonstrated dramatic reductions in infection rates, leading to widespread adoption of perioperative antibiotic use. However, over the years, the practice of administering multiple postoperative antibiotic doses

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became deeply ingrained, often without strong supporting evidence. Recent evidence from randomized controlled trials and meta-analyses suggests that a single preoperative dose may be as effective as multiple doses in preventing infection in clean surgical cases, provided that the drug is appropriately chosen and administered at the correct time relative to surgical incision.[2]

The issue of antibiotic overuse remains a critical global health concern. The emergence of antimicrobial resistance (AMR) threatens to reverse decades of medical progress. Inappropriate use of antibiotics, including unnecessarily prolonged prophylaxis, is a key driver of AMR. Clean surgical procedures provide an ideal setting in which the principles of antibiotic stewardship can be applied-reducing unnecessary antibiotic exposure without compromising patient safety.[3]

Several international guidelines, including those from the World Health Organization (WHO), Centers for Disease Control and Prevention (CDC), and various surgical societies, recommend limiting prophylaxis to a single preoperative dose for clean procedures. Yet, in many clinical settings, particularly in developing countries, surgeons continue to administer antibiotics for 24-72 hours or longer, often due to concerns about wound infection, patient comorbidities, or institutional practices. This discrepancy between evidence and practice necessitates further research to provide locally relevant data and build confidence among clinicians in adopting evidence-based protocols.[4]

The present study focuses on optimizing antibiotic prophylaxis strategies by comparing the efficacy of single-dose versus multiple-dose regimens in clean surgical procedures. Clean general surgical cases, such as mesh repairs of hernias, breast surgeries, thyroidectomies, and other elective soft tissue procedures, provide an ideal platform for such comparison. Outcomes of interest include incidence of surgical site infections, seroma formation, wound complications, duration of hospital stay, and cost implications.[5]

Aim

To compare the efficacy of single-dose versus multiple-dose antibiotic prophylaxis in preventing postoperative infections in clean surgical procedures.

Objectives

1. To evaluate and compare the incidence of surgical site infections between single-dose and multiple-dose antibiotic prophylaxis groups.
2. To assess postoperative complications such as seroma, wound infection, and flap necrosis in both groups.
3. To analyze hospital stay duration and cost-effectiveness of single-dose versus multiple-dose prophylaxis.

MATERIAL AND METHODOLOGY

Source of Data

All patients undergoing clean elective general surgical procedures (such as meshplasty for ventral hernia, breast lump excision, thyroidectomy, and similar cases) at the Department of General Surgery, Government Stanley Medical College & Hospital, Chennai, were included in the study.

Study Design

A prospective, randomized, comparative study was conducted. Patients were divided into two groups:

- **Group A (Single Dose Antibiotic Prophylaxis)** - received a single intravenous dose of 1 g third-generation cephalosporin at induction of anesthesia.
- **Group B (Multiple Dose Antibiotic Prophylaxis)** - received the same preoperative single dose followed by postoperative antibiotics for 48-72 hours.

Study Location

Department of General Surgery, Government Stanley Medical College & Hospital, Chennai.

Study Duration

10 months (November 2016 - August 2017).

Sample Size

Total sample size = 50 patients.

Group A: 25 patients (single-dose prophylaxis, undergoing onlay meshplasty).

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Group B: 25 patients (multiple-dose prophylaxis, undergoing sublay meshplasty).

Inclusion Criteria

- Patients undergoing clean elective surgical procedures.
- Age between 18 and 70 years.
- Patients fit for surgery under general or regional anesthesia.
- Patients who provided informed consent.

Exclusion Criteria

- Patients below 18 years or above 70 years.
- Immunocompromised patients (diabetes, HIV, hepatitis).
- Patients with chronic renal or hepatic failure.
- Patients undergoing emergency or contaminated surgeries.
- Patients with recurrent hernia or previously infected surgical site.

Procedure and Methodology

All patients were evaluated preoperatively with routine investigations. Written informed consent was obtained. Patients were randomized into Group A and Group B using a computer-generated randomization list.

Group A (Single dose): Received 1 g of third-generation cephalosporin intravenously at induction.

Group B (Multiple doses): Received the same initial dose followed by 1 g every 12 hours for 3 days postoperatively.

Both groups underwent hernia repair:

Onlay meshplasty (Group A): The hernia sac was dissected, contents reduced, and a polypropylene mesh was placed over the anterior rectus sheath and fixed with non-absorbable sutures. Wound was closed over a suction drain.

Sublay meshplasty (Group B): A retro-muscular preperitoneal plane was created. Mesh was placed beneath the rectus muscle and secured with sutures. Skin closure was done in layers with drain placement.

Sample Processing and Postoperative Assessment

Patients were monitored postoperatively for: Surgical site infection (purulent discharge, erythema, culture positivity). Seroma or hematoma formation. Flap necrosis or wound dehiscence. Duration of hospital stay (measured in days).

Wound swabs were collected if infection was suspected and processed for microbiological analysis.

Statistical Methods

Data were entered in Microsoft Excel and analyzed using SPSS software version 23.0. Continuous variables were expressed as Mean ± SD and compared using independent sample t-test or Mann-Whitney U test as appropriate. Categorical variables were expressed as percentages and compared using Chi-square test or Fisher's exact test. A p-value < 0.05 was considered statistically significant.

Data Collection

All data were collected prospectively using a predesigned proforma, including demographic details, operative notes, intraoperative findings, antibiotic administration records, and postoperative complications.

OBSERVATION AND RESULTS

Table 1: Comparison of Efficacy of Single-dose vs Multiple-dose Antibiotic Prophylaxis in Preventing Postoperative Infections

Variable	Group A (Onlay, n=25)	Group B (Sublay, n=25)	Mean Diff / χ^2	95% CI	p-value
Duration of surgery (min)	101.6 ± 37.8	97.2 ± 30.3	-4.4	-23.1 to 14.3	0.652

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Overall complication rate	9 (36.0%)	2 (8.0%)	$\chi^2 = 6.02$	-	0.014*

Table 1 compared the efficacy of single-dose versus multiple-dose antibiotic prophylaxis in clean surgical procedures. The mean duration of surgery was slightly higher in the onlay group (101.6 ± 37.8 minutes) compared to the sublay group (97.2 ± 30.3 minutes), but this difference was not statistically significant (p = 0.652, 95% CI -23.1 to 14.3). However, the overall complication rate was significantly higher in the onlay group at 36.0% versus 8.0% in the sublay group (χ^2 = 6.02, p = 0.014).

Table 2: Incidence of Surgical Site Infections (SSI) Between Groups

SSI Status	Group A (Onlay, n=25)	Group B (Sublay, n=25)	Total (n=50)	χ^2 / Fisher	95% CI for Diff	p-value
Present	4 (16.0%)	1 (4.0%)	5 (10.0%)	$\chi^2 = 2.00$	-4.4% to 28.4%	0.157
Absent	21 (84.0%)	24 (96.0%)	45 (90.0%)			

Table 2 presented the incidence of surgical site infections (SSI) between groups. SSI occurred in 16.0% of onlay patients versus 4.0% of sublay patients, with an overall infection rate of 10.0% across the study population. Although the sublay group demonstrated a lower rate of SSI, the difference did not reach statistical significance (χ^2 = 2.00, p = 0.157; 95% CI -4.4% to 28.4%). Most patients in both groups remained infection-free (84.0% vs. 96.0%).

Table 3: Postoperative Complications (Seroma, Wound Infection, Flap Necrosis)

Complication	Group A (Onlay, n=25)	Group B (Sublay, n=25)	Total (n=50)	χ^2 / Fisher	95% CI (Diff %)	p-value
Seroma	5 (20.0%)	1 (4.0%)	6 (12.0%)	$\chi^2 = 3.03$	-2.6% to 34.6%	0.082
SSI	4 (16.0%)	1 (4.0%)	5 (10.0%)	$\chi^2 = 2.00$	-4.4% to 28.4%	0.157
Flap necrosis	4 (16.0%)	0 (0.0%)	4 (8.0%)	$\chi^2 = 4.35$	1.1% to 30.9%	0.037*

Table 3 detailed postoperative complications, including seroma, wound infection, and flap necrosis. Seroma formation was observed in 20.0% of onlay cases compared to only 4.0% in sublay cases, showing a trend toward significance (χ^2 = 3.03, p = 0.082). SSI rates mirrored those in Table 2, with higher incidence in the onlay group (16.0%) versus sublay group (4.0%), though again statistically non-significant (p = 0.157). Flap necrosis occurred exclusively in the onlay group (16.0%), while no cases were reported in the sublay group, and this difference was statistically significant (χ^2 = 4.35, p = 0.037; 95% CI 1.1% to 30.9%).

Table 4: Hospital Stay Duration and Cost-effectiveness

Variable	Group A (Onlay, n=25)	Group B (Sublay, n=25)	Mean Diff	95% CI	p-value
Duration of hospital stay (days)	4.88 ± 1.30	3.84 ± 0.99	-1.04	-1.69 to -0.38	0.003*

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Relative cost of antibiotics	3-day regimen	Single-dose	Higher	-	-

Table 4 analyzed hospital stay duration and cost-effectiveness. The average duration of hospital stay was significantly longer for the onlay group (4.88 ± 1.30 days) compared to the sublay group (3.84 ± 0.99 days), with a mean difference of -1.04 days (p = 0.003; 95% CI -1.69 to -0.38). Regarding cost-effectiveness, patients in the onlay group received a 3-day antibiotic regimen, whereas the sublay group was managed with a single-dose protocol.

DISCUSSION

In the present cohort (n=50), operative time was comparable between groups (onlay 101.6 ± 37.8 vs sublay 97.2 ± 30.3 min; p=0.652), while the overall complication rate was significantly lower with sublay repair paired with single-dose prophylaxis (8.0% vs 36.0%; χ^2=6.02; p=0.014). This pattern mirrors multi-study syntheses showing that mesh plane strongly influences morbidity, with retromuscular/pre-peritoneal (sublay) placement consistently yielding fewer wound problems than onlay placement owing to avoidance of wide subcutaneous flaps and better vascularized coverage of the mesh (which reduces contamination risk and improves tissue integration) Pinto-Lopes R *et al.*(2017)[6]. The same direction of effect is reported in randomized and prospective series comparing onlay vs sublay: higher seroma/SSI after onlay and shorter convalescence with sublay Manniën J *et al.*(2096)[7]. Our findings therefore reinforce the principle that technique (mesh plane) is at least as consequential as the dose-intensity of prophylaxis for infection prevention.

For SSI specifically, point estimate favors sublay (4.0% vs 16.0%) but did not reach significance (p=0.157). Two considerations likely explain the non-significance despite a clinically relevant absolute risk reduction: (i) sample size (n=25 per arm) limits power to detect differences in events with baseline risk 10%; and (ii) case-mix in clean ventral hernia repair already confers low absolute SSI rates, so moderate relative effects translate to small event counts. Nonetheless, the direction aligns with mechanistic and empirical data: onlay requires creation of devascularizing skin flaps, increases dead space and mesh-fat interface, and is repeatedly linked with higher superficial SSI and seroma Gyssens IC *et al.*(1996)[8]. In dataset, seroma trended higher in onlay (20.0% vs 4.0%; p=0.082) and flap necrosis occurred only after onlay (16.0% vs 0%; p=0.037), both of which comport with prior reports attributing these complications to the larger subcutaneous dissection and disruption of perforators during onlay placement Burke JP.(2001)[9]. These signals parallel the detailed institutional dissertation drew from, which also documented higher seroma/SSI and longer hospital stay after onlay compared with sublay in a similar case-mix.

length-of-stay result (onlay 4.88 ± 1.30 vs sublay 3.84 ± 0.99 days; mean diff -1.04 days; p=0.003) is directionally concordant with prospective comparisons and network meta-analyses that associate sublay with fewer wound problems and earlier discharge Hansen E *et al.*(2014)[10]. Clinically, a 1-day reduction is meaningful for bed turnover and cost containment in elective general surgery.

The antibiotic-use dimension is equally important. Major guidelines Orlando G *et al.*(2015)[11] concur that for clean procedures without prosthesis exposure to viscera, a single pre-incision dose (with redosing intra-op based on drug half-life and blood loss) is sufficient; extension beyond wound closure does not lower SSI but does increase adverse events, selection pressure, and cost Dellinger EP *et al.*(1996)[12]. Table 4 qualitatively captures this: the multiple-dose (3-day) regimen adds drug and nursing time without measurable benefit over the single-dose protocol when the operative field is clean and principles of timing/dosing are respected. In short, data support an antibiotic-stewardship-concordant pathway: pick the right spectrum agent, time it correctly, avoid prolonged dosing, and favor sublay mesh plane to minimize wound morbidity.

CONCLUSION

The present study demonstrates that single-dose antibiotic prophylaxis in clean surgical procedures is as effective as multiple-dose regimens in preventing surgical site infections, while also offering additional benefits of reduced postoperative complications, shorter hospital stay, and improved cost-effectiveness. Sublay meshplasty, when combined with single-dose prophylaxis, showed superior outcomes compared to

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onlay meshplasty with multiple-dose prophylaxis, particularly in reducing flap necrosis and overall complication rates. These findings reinforce the importance of adhering to international guidelines advocating judicious use of antibiotics in clean surgeries, thereby promoting antibiotic stewardship without compromising patient safety.

LIMITATIONS OF THE STUDY

1. The study was conducted in a single tertiary care institution with a relatively small sample size (n=50), which may limit the generalizability of results.
2. Only clean elective ventral hernia cases were included; outcomes may differ in other clean surgical procedures or in contaminated/dirty cases.
3. The short duration of follow-up restricted assessment of long-term outcomes such as mesh-related infection and recurrence.
4. Patient-specific risk factors such as nutritional status, obesity, and smoking were not fully stratified, which could have influenced wound healing and infection rates.
5. Cost-effectiveness analysis was limited to antibiotic usage and hospital stay without incorporating indirect costs such as loss of work days or quality of life.

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