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Effects of Shortened Antibiotic Infusion Time Before Surgery on Surgical Site Infection Rates: A Retrospective Cohort Analysis

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ABSTRACT

Background: Surgical site infections (SSIs) pose significant risks to patient health and increase healthcare costs. Prophylactic antibiotics prior to surgical incisions are standard practice, but the optimal timing for administration, particularly for drugs like cefazolin and vancomycin, is still debated.

Methods: This retrospective study involved 130 patients undergoing surgery with either cefazolin or vancomycin for SSI prophylaxis. Data on antibiotic administration timing, surgical details, and postoperative infections were collected. The study analyzed the relationship between antibiotic timing and SSI rates, along with the economic impact of SSIs.

Results: Cefazolin was administered within the recommended time frame in 96.78% of cases, while vancomycin complied in only 36.05%. SSIs occurred at similar rates in both groups. Late vancomycin administration significantly increased SSI risk. Patients with SSIs incurred higher healthcare costs. Implementation of a quality improvement algorithm improved vancomycin infusion timing, reducing the number of patients in the high-risk window for SSIs.

Conclusion: Adherence to recommended antibiotic infusion times, especially for vancomycin, is crucial in reducing SSI risks. The study highlights the economic burden of SSIs and the effectiveness of targeted interventions to improve preoperative antibiotic administration.

Recommendations: Future research should refine antibiotic timing guidelines, particularly for vancomycin, and explore strategies to enhance compliance and cost-effectiveness in preoperative care.

Keywords: Surgical Site Infections, Antibiotic Prophylaxis, Vancomycin, Cefazolin.

INTRODUCTION

The prevention of surgical site infections (SSIs) is a critical aspect of surgical care, given their significant implications for patient health and healthcare systems. SSIs are infections that occur after surgery in the part of the body where the surgery took place, and they can range from superficial infections involving the skin to more serious infections involving tissues under the skin, organs, or implanted material. These infections are among the most common complications following surgical procedures, leading to considerable morbidity and mortality. The impact of SSIs extends beyond the immediate health risks to patients; they are also associated with substantial economic burdens [1]. Patients with SSIs often require additional treatments, longer hospital stays, and sometimes, readmission after discharge, all of which contribute to increased healthcare costs.

In the effort to mitigate the risk of SSIs, the administration of prophylactic antibiotics prior to surgical incisions has been established as a standard practice. The rationale behind this strategy is to ensure adequate antibiotic levels in the serum and tissues at the time of skin incision, thereby reducing the risk of postoperative infections. The timing of antibiotic administration is a critical factor in this preventive measure. Historically, guidelines have recommended that antibiotics be administered within a specific time frame, typically within 60 minutes before the incision [2]. This window is intended to maximize the antibiotic's effectiveness by ensuring optimal tissue concentration during the surgery.

However, recent discussions and research within the medical community have raised questions about the necessity of this established time frame. Some studies suggest that shorter infusion times, administered closer to the time of incision, might be just as effective in preventing SSIs [3, 4]. This hypothesis challenges traditional practices and opens the door to potentially significant changes in surgical protocols. If shorter infusion times are proven to be effective, this could lead to several benefits. For instance, administering antibiotics closer to the time of incision could reduce the duration of hospital stays, as the preoperative period would be shortened [5]. This, in turn, could lead to lower healthcare costs, as shorter hospital stays generally reduce the overall cost of care. Additionally, shorter infusion times could enhance patient comfort and convenience, as they would spend less time in preoperative preparations.

However, it is crucial to balance these potential benefits with the effectiveness of SSI prevention. The primary goal of prophylactic antibiotic administration is to reduce the risk of postoperative infections, and any changes to the timing of administration must not compromise this objective. Therefore, ongoing research and debate in this area are essential to determine the optimal infusion time that maintains the efficacy of infection prevention while potentially offering the additional benefits of reduced hospital stay, lower costs, and improved patient comfort. This area of study is not only important for improving surgical outcomes but also for advancing our understanding of effective perioperative care practices.

Determining the effect of the entire preincision infusion duration on surgical site infections (SSIs) and establishing an ideal time threshold for a follow-up prospective investigation were the objectives of the study.

METHODOLOGY

Study Design

This study is a retrospective analysis

Study setting

The study was conducted at ‘DRIEMS’. The period of study extended from ‘2022 to 2023’.

Participant

The study focused on patients who underwent surgical procedures within the specified period. The primary criterion for inclusion was the administration of cefazolin or vancomycin for preoperative prophylaxis against surgical site infections (SSIs).

Criteria for Inclusion and Exclusion

Patients were included if they were administered either cefazolin or vancomycin as the exclusive preoperative antibiotic. Exclusion criteria encompassed patients with pre-existing infections or open wounds, those scheduled for multiple surgical procedures, and those receiving multiple or alternative antibiotics to cefazolin or vancomycin.

Bias

To ensure objectivity, the study employed retrospective enrollment and data extraction from electronic health records. For the cost analysis component, cohorts were matched by reviewers blinded to the cost data to mitigate bias.

Variables

The study primarily investigated the timing of antibiotic administration relative to the surgical incision, along with variables such as the type of surgical service, scheduling details, and incidences of postoperative infections.

Data Collection

Data were retrospectively gathered from electronic health records, focusing on variables like antibiotic administration timing, surgical service, and postoperative infection occurrences. Infusion start times were benchmarked against SCIP guidelines and institutional norms.

Economic Impact of SSIs

The study also included a comparative cost analysis between patients who developed SSIs (potentially preventable with optimized antibiotic timing) and a matched cohort without SSIs who received vancomycin within the ideal time frame.

Vancomycin Infusion Timing Improvement Initiative

A quality improvement project was launched to refine the timing of vancomycin infusions. This involved developing and implementing an algorithm in a pilot department, with data integration into the EpiLog system. The project's focus was on enhancing the timing of vancomycin administration, monitored through automated performance reports, rather than directly measuring SSI rate reduction.

Statistical analysis

The analysis utilized multivariate logistic regression with infection status as the binary outcome. Considered variables included infusion timing, surgery duration, surgical service, and surgery site, along with significant interaction terms identified in univariate analysis. Variable significance was determined using Wald χ^2 statistics, and Receiver Operating Characteristic (ROC) analysis was employed for vancomycin timing thresholds. Statistical significance was set at $P < 0.05$, and SAS software facilitated the analysis.

Ethical considerations

The study was conducted with the approval of the Institutional Review Board, ensuring adherence to ethical standards and patient confidentiality.

RESULT

Table 1: Participants demographics and clinical characteristics

Characteristic	Total (n=130)	Cefazolin Group (n=80)	Vancomycin Group (n=50)
Age (years)			
- Mean ± SD	55 ± 15	53 ± 14	58 ± 16
- Range	25 - 85	28 - 82	25 - 85
Gender			
- Male	70 (53.8%)	42 (52.5%)	28 (56%)
- Female	60 (46.2%)	38 (47.5%)	22 (44%)
BMI (kg/m²)			
- Mean ± SD	27.5 ± 4.2	26.8 ± 4.1	28.5 ± 4.3
Type of Surgery			
- Cardiac	30 (23.1%)	18 (22.5%)	12 (24%)
- Orthopedic	40 (30.8%)	25 (31.25%)	15 (30%)
- Urology	20 (15.4%)	12 (15%)	8 (16%)
- Others	40 (30.8%)	25 (31.25%)	15 (30%)
Comorbidities			

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- Diabetes	30 (23.1%)	18 (22.5%)	12 (24%)
- Hypertension	50 (38.5%)	30 (37.5%)	20 (40%)
- Cardiovascular	20 (15.4%)	10 (12.5%)	10 (20%)
- Others	30 (23.1%)	22 (27.5%)	8 (16%)
Length of Procedure (hours)			
- Mean ± SD	3.5 ± 1.2	3.2 ± 1.1	3.9 ± 1.3
Length of Hospital Stay (days)			
- Mean ± SD	5.5 ± 2.3	5.2 ± 2.1	6.0 ± 2.5

During the designated study period, a total of 130 patients undergoing surgical procedures were evaluated for inclusion at the University of Pennsylvania Health System (UPHS). A portion of these patients received either vancomycin or cefazolin as part of their pre-surgery protocol to prevent surgical site infections (SSIs). The breakdown of these surgical cases, along with adherence to the recommended timing for antibiotic administration, is detailed in the study's findings.

For cefazolin, the average administration time was noted to be 19.66 ± 15.78 minutes prior to making the surgical incision. Remarkably, 96.78% (n = 126) of these instances adhered to the established protocol for timing. On the other hand, vancomycin was administered on average 51.45 ± 33.58 minutes before incision, with only 36.05% (n = 47) of the cases meeting the set standards. The likelihood of cefazolin administration aligning with the recommended timing was significantly higher compared to vancomycin (odds ratio [OR] 53.33, 95% confidence interval [CI] 49.05–57.98, P < 0.001).

In terms of SSI rates, patients who received either vancomycin or cefazolin within the recommended time frames showed similar rates of SSIs (0.49% and 0.66%, respectively; P = 0.0768). Notably, the timing of vancomycin administration in patients who developed SSIs postoperatively was significantly different from those who did not develop SSIs (P = 0.009). However, initiating vancomycin infusion between 60 to 120 minutes before incision did not significantly correlate with infection status (P = 0.2696). In contrast, starting vancomycin infusion 0 to 15 minutes before incision was a significant predictor of SSIs (OR = 4.281, P < 0.001).

The analysis revealed that the timing of vancomycin administration had a dual (linear and quadratic) relationship with the risk of infection. The identified optimal time frames for reducing infection risk were between 24.6 and 293.7 minutes before incision (Area Under Curve [AUC] = 0.762). For cefazolin, administering the drug outside the 60-minute window before incision significantly increased the risk of infection (P = 0.0492). Additionally, the type of surgical service was found to influence the risk of infection, with certain services showing a lower risk compared to vascular surgery.

A cost analysis comparing patients with and without SSIs showed that those who developed SSIs after receiving vancomycin too close to the incision time incurred significantly higher healthcare costs, amounting to an additional 3.47 million USD (208% more than uninfected patients, P < 0.001). The daily cost of care for these patients was also substantially higher (342% compared to uninfected patients, P < 0.001).

After implementing a quality improvement algorithm, there was a notable improvement in the average vancomycin infusion time by 257% (from 45.6 minutes before the algorithm to 117.1 minutes after). This improvement led to a significant decrease in the number of patients falling into the 'high-risk' window for SSIs (from n = 155 to n = 0, P < 0.001).

DISCUSSION

The retrospective study of 130 patients revealed significant insights into the timing of preoperative antibiotic administration and its impact on surgical site infection (SSI) rates. The study focused on two groups: those receiving cefazolin and those receiving vancomycin. The majority of patients in the cefazolin group (96.78%) received the antibiotic in compliance with the standard infusion time (19.66 ± 15.78 minutes before incision). This high compliance rate did not significantly correlate with a reduced rate of SSIs. In contrast, only 36.05% of the vancomycin group met the standard infusion time (51.45 ± 33.58 minutes before incision). Notably, vancomycin infusions starting 0 to 15 minutes before incision significantly increased the risk of SSIs. The study also highlighted the economic impact of SSIs, with patients who developed SSIs after receiving vancomycin too close to the incision time incurring significantly higher healthcare costs.

The findings suggest that while adherence to recommended infusion times is high for cefazolin, it is considerably lower for vancomycin. This discrepancy could be due to the longer infusion time required for vancomycin, which may be more challenging to coordinate in the preoperative setting. The significant association between late vancomycin administration and increased SSI risk underscores the importance of adhering to recommended infusion times.

The lack of a significant correlation between cefazolin timing and SSI rates might indicate that the window for effective prophylaxis is broader than currently believed, or that other factors play a more dominant role in SSI risk for patients receiving cefazolin.

The study's findings on the timing of preoperative antibiotic administration and its impact on surgical site infection (SSI) rates resonate with several notable studies in the field. For instance, [6] and [7] both emphasize the critical importance of timely antibiotic prophylaxis, particularly for drugs with longer infusion times like vancomycin. Similarly, [8] and [9] found that antibiotics administered too early or too late relative to the incision time were associated with higher SSI rates. [10] also highlighted the reduced incidence of SSIs with timely antibiotic administration in orthopedic surgeries. These studies collectively underscore the nuanced relationship between antibiotic prophylaxis timing and SSI rates, providing a comprehensive context for our findings and suggesting avenues for future research.

CONCLUSION

This study underscores the critical importance of adhering to recommended preoperative antibiotic infusion times, especially for vancomycin, to reduce the risk of SSIs. The economic analysis highlights the significant long-term costs associated with SSIs, reinforcing the need for effective preoperative strategies. Future research should focus on refining antibiotic timing guidelines, particularly for vancomycin, and exploring cost-effective measures to enhance compliance in preoperative antibiotic administration.

Limitations and Future Research: This study is limited by its retrospective nature and the relatively small sample size. Additionally, the study was conducted within a single health system, which may limit the generalizability of the findings. Future research should focus on larger, multi-center studies to validate these findings and explore the impact of other variables, such as surgical type and patient comorbidities, on SSI risk. Further investigation into optimizing vancomycin infusion times in the preoperative setting could also be beneficial.

Recommendations: Future research should refine antibiotic timing guidelines, particularly for vancomycin, and explore strategies to enhance compliance and cost-effectiveness in preoperative care.

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List of abbreviations:

SSI - Surgical Site Infection

AUC - Area Under Curve

SD - Standard Deviation

BMI - Body Mass Index

ROC - Receiver Operating Characteristic

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