Original Article

Preoperative Antibiotic Prescribing for Appendectomy and Cholecystectomy at a Community Hospital in West Texas

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Abstract

Background: Guidelines for appendectomy and cholecystectomy surgery recommend a first- or second-generation cephalosporin with anaerobic coverage to prevent infection. Despite this recommendation, broad-spectrum antibiotics are often used.

Objectives:
The primary objective of this study was to determine the frequency of alignment of pre-operative antibiotics with guideline-recommended regimens for appendectomy and cholecystectomy. Secondary objectives included assessing therapy duration, penicillin allergy, costs, and prescriber factors.

Methods:
This retrospective observational cohort study included patients undergoing appendectomy or cholecystectomy between January 1, 2024, and July 31, 2024, at a community hospital in West Texas. Data collected included patient demographics, procedure type, antibiotics, duration of therapy, costs, and prescriber type. Statistical analyses included descriptive statistics for demographics and costs; chi-square or Fisher's Exact tests to compare antibiotic prescribing by procedure type; and logistic regression to identify factors associated with guideline adherence and antibiotic costs.

Results:
Of the 239 subjects identified, 169 were included. Alignment of pre-operative antibiotics with guideline-recommended therapy was 36.7% (12.5% appendectomy; 58.4% cholecystectomy). The average duration of antibiotic therapy varied by antibiotic (range: 1-11 days). Many patients (49.7%) received >1 pre-operative dose. Documented penicillin allergy was noted in 11.8%. Prescriber patterns varied by provider specialty and clinical setting.

Conclusions:
Alignment of pre-operative antibiotics prescribing with guideline-recommended regimens for appendectomy and cholecystectomy was relatively low. Quality improvement measures should be initiated to improve prescribing.

Keywords: antimicrobial stewardship; pre-operative antibiotics; appendectomy, cholecystectomy

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Introduction

Approximately 160,000 to 300,000 surgical site infections (SSIs) occur in the United States each year.[1] Pre-operative antibiotics prior to commonly performed surgeries, such as appendectomies and cholecystectomies, are critical to avoid infections, which can lead to increased hospital stay, costs, and morbidity and mortality.[1]

The 2013 American Society of Health-System Pharmacists (ASHP), the Infectious Disease Society of America (IDSA), the Surgical Infection Society (SIS), and the Society for Healthcare Epidemiology of America (SHEA), along with the 2025 World Society Emergency Surgery guidelines, recommend pre-operative intravenous antibiotics for all patients with suspected appendicitis, even uncomplicated cases, to prevent SSI.[2,3] For uncomplicated appendicitis, appropriate prophylaxis includes a single dose of a first-generation cephalosporin (e.g., cefazolin) with metronidazole or a second-generation cephalosporin with anaerobic activity (i.e., cefoxitin or cefotetan).[2] Most SSIs after appendectomy involve anaerobic and aerobic gram-negative bacteria, with *Bacteroides fragilis* and *E. coli* being the most common. Other organisms may include *streptococci*, *Staphylococcus* species, *Enterococcus*, and, infrequently, *Pseudomonas aeruginosa*.[2]

Biliary tract procedures, such as cholecystectomy, typically involve a sterile biliary tract.[2] A single dose of cefazolin is recommended for open biliary procedures; alternatives include ampicillin-sulbactam and other cephalosporins (cefoxitin, ceftriaxone, and cefotetan).[2,4-7] Current guidelines state pre-operative antibiotics are not generally needed for low-risk elective laparoscopic cholecystectomy but are advised for higher-risk cases, such as patients with diabetes, longer procedures (>120 min), risk of gallbladder rupture, or patients over 70 years of age.[2] Common organisms post-procedure are *E. coli, Klebsiella*, and *enterococci*, with less frequent reports of other gram-negatives, streptococci, staphylococci, and sometimes anaerobes like *Clostridium*.[2,4,5]

Despite guideline recommendations to use narrow-spectrum antibiotics to target common organisms, the available literature indicates that many patients receive broad-spectrum antibiotics.[8] Ideally, an antimicrobial agent used pre-operatively should prevent SSI, reduce SSI-related morbidity and mortality, lower the duration and cost of healthcare, produce no adverse effects, and have no negative impact on the microbial flora.[2] Antibiotics can predispose patients to *Clostridium difficile*-associated colitis. Risk factors for developing *C. difficile*-associated colitis include longer durations of pre-operative therapy and the use of multiple antimicrobial agents. Limiting the duration of pre-operative antibiotics to a single dose can reduce the risk of *C. difficile* disease.[9]

Objectives

The primary objective of this study was to determine the frequency of alignment between preoperative antibiotic prescribing and guideline-recommended regimens for appendectomy and cholecystectomy at a community hospital in West Texas. Secondary objectives included evaluating the duration of antibiotic therapy, examining the frequency of penicillin allergy and its impact on antibiotic selection, estimating costs of antibiotic treatments, and exploring factors influencing prescribers' antibiotic choices.

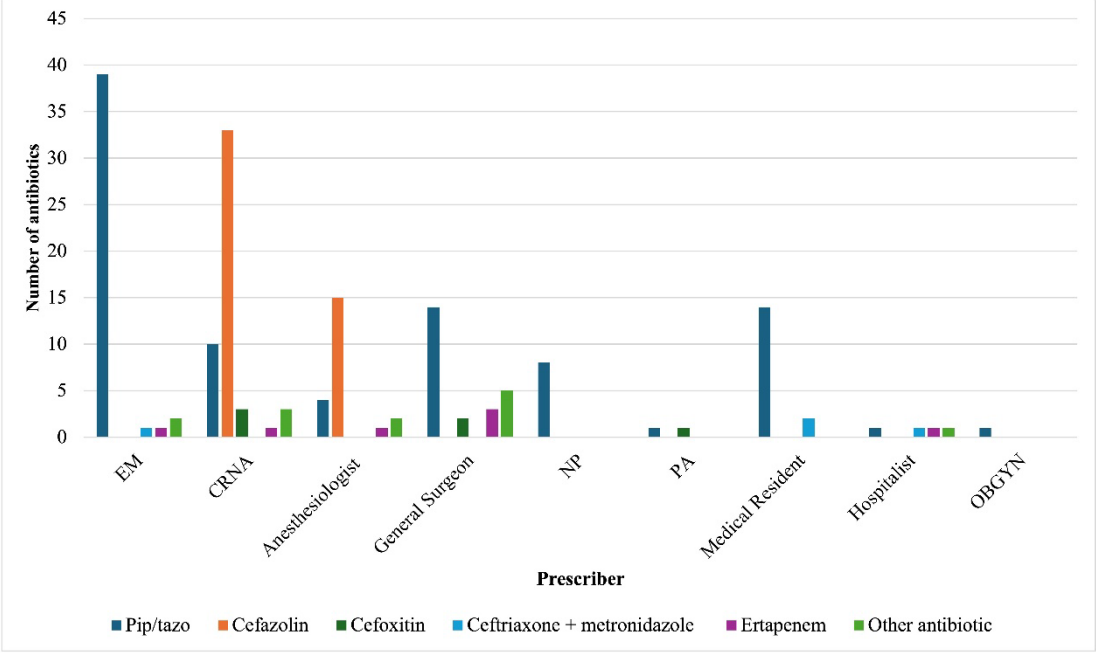
Methods

Study Design and Participants

This retrospective observational cohort study included adult and pediatric patients admitted to a tertiary care hospital in West Texas who underwent appendectomy or cholecystectomy between January 1, 2024, and July 31, 2024. The study setting and time frame were defined a priori. Based on institutional surgical volume data, the average monthly number of these surgeries was approximately 35, and it was anticipated that approximately 200 medical records would be available for review over a seven-month period. This study was reviewed and deemed exempt by the Texas Tech University Health Sciences Center Institutional Review Board.

Eligible participants included all adults and pediatric patients undergoing

Figure 1. Pre-operative Antibiotics Prescribed Across Type of Providers



EM, Emergency Medicine; CRNA, Certified Registered Nurse Anesthetists; NP, Nurse Practitioner; PA, Physician Assistant; Pip/tazo; Piperacillin/Tazobactam; OBGYN, Obstetrics and Gynecology

appendectomy and cholecystectomy procedures during the study period. Patients were excluded if they had a positive pregnancy test, given the unique physiological considerations that may complicate outcome interpretation; experienced post-operative complications, to maintain a more homogeneous cohort for comparison; had active or residual infections; or had complicated appendicitis (e.g., perforated or gangrenous disease), as these cases typically require broad-spectrum antibiotics and longer treatment durations. In addition, prisoners or wards of the state were excluded to prevent the inclusion of vulnerable populations that require extra protections beyond the scope of this study.

Data collection

Data were collected through a retrospective manual review of electronic medical records using a standardized data abstraction process. Patient information was initially stored in a password-protected file on a secure hospital server accessible only to authorized hospital personnel. Following data abstraction, all patient identifiers were removed, and de-identified data were transferred to an encrypted, password-protected Microsoft Excel spreadsheet stored on a secure network server with access limited to study investigators.

Collected variables included a unique study identification number; de-identified patient demographic characteristics (i.e., age, sex, race, height, weight, calculated BMI); surgical procedure type (appendectomy or cholecystectomy); admission date, procedure date, discharge date, and hospital length of stay. Clinical variables included antibiotic agents prescribed; number of doses administered; duration of antibiotic therapy; use of additional antimicrobial agents; penicillin allergy status and documented reaction type; and the cost of antibiotics. Prescriber characteristics, including provider type (e.g., MD/DO, NP, PA) and specialty, were also collected to evaluate prescribing patterns.

Statistical Analysis

All analyses were conducted using STATA/IC15.1 (StataCorp, College Station, TX) and Microsoft Excel. Descriptive analyses were used to summarize patient demographics,

surgical characteristics, antibiotic prescribing patterns, rates of guideline adherence, therapy durations, penicillin allergy status, costs, and prescriber type. Categorical variables were summarized using frequencies and percentages, while continuous variables were summarized using means and standard deviations, or medians and interquartile ranges, as appropriate.

Comparative analyses were performed to evaluate the associations between patient and prescriber characteristics and guideline-recommended antibiotic prescribing. Chi-square or Fisher's Exact tests were used for categorical values, as appropriate. Logistic regression models were constructed to identify factors independently associated with guideline adherence and antibiotic-related costs. Variables included in multivariable models were selected based on clinical relevance and univariable associations. Statistical significance was defined as a two-sided p-value <0.05. Analyses were conducted using complete-case data.

Table 1. Demographics and Baseline Characteristics (n=169)

Characteristics of Adult Patients (n=145)		
Sex		
	Male — no. (%)	48 (33)
	Female — no. (%)	97 (67)
Race		
	White — no. (%)	84 (58)
	Black or African American — no. (%)	6 (4)
	Asian — no. (%)	1 (1)
	Other — no. (%)	54 (37)
Penicillin Allergy — no. (%)		18 (12)
Age, mean ± SD (range)		42 ± 16 (18-89)
BMI, mean ± SD (range)		30.7 ± 7.4 (14.2-51.4)
Characteristics of Pediatric Patients (n=24)		
Sex		
	Male — no. (%)	11 (46)
	Female — no. (%)	13 (54)
Race		
	White — no. (%)	11 (46)
	Black or African American — no. (%)	0 (0)
	Asian — no. (%)	1 (4)
	Other — no. (%)	12 (50)
Penicillin Allergy — no. (%)		2 (8)
Age, mean ± SD (range)		12 ± 4 (2-17)
BMI, mean ± SD (range)		22.2 ± 7.1 (14.2 – 42)

BMI, Body Mass Index; SD, Standard Deviation

Results

From January 1, 2024, to July 31, 2024, a total of 239 patient charts were identified for possible inclusion. Seventy charts were excluded, including 64 with suppurative or perforation disease identified postoperatively and 4 patients

who received antibiotic therapy for an active infection (urinary tract infection, pneumonia, or bacteremia). Two pregnant patients were also excluded. The final study population consisted of 169 patients. Most patients were adult females with a mean body mass index (BMI) in the obesity range. Pediatric patients comprised a small proportion of the cohort. Baseline demographics are depicted in Table 1.

Of the 169 patients included in the analysis, alignment between prescribed pre-operative antibiotics and guideline recommendations was 36.7% of cases when both procedures were considered together ($p<0.001$). When stratified by procedure, guideline alignment was 12.5% for appendectomy ($p<0.001$) and 58.4% for cholecystectomy ($p<0.001$). Piperacillin-tazobactam was the most frequently prescribed antibiotic, used in 92 cases (54.4%). Antibiotics received and the duration of therapy during hospital stay are listed in Table 2.

For appendectomy, among the 80 cases included, the guideline-recommended agents were prescribed as follows: cefazolin plus metronidazole in 6.3% of cases and ceftriaxone plus metronidazole in 1%. The remaining guideline-recommended agents, including cefoxitin, cefotetan, or ampicillin-sulbactam, were not prescribed in the appendectomy cases. The remaining agents not recommended by guidelines, including piperacillin-tazobactam, were prescribed in 64 cases (80%), cefazolin in 2 cases (2.5%), ertapenem in 4 cases (5%), and other antibiotics, including cefepime, ciprofloxacin plus metronidazole, or levofloxacin plus metronidazole, in 4 cases (5%).

For cholecystectomy, of the 89 cases, the guideline-recommended agent, cefazolin, was prescribed in 46 cases (51.7%). The remaining patients (48.3%) received broader-spectrum antibiotics, including piperacillin-tazobactam (31.5%), cefoxitin (1%), ceftriaxone plus metronidazole (3%), ertapenem (2%), and other antibiotics (10.1%), such as meropenem, ciprofloxacin plus metronidazole, or clindamycin in patients with a documented penicillin allergy.

The duration of antibiotic therapy varied among agents. Approximately half of the patients (n=84; 49.7%) received more than one preoperative dose, either before or after surgery. Among these patients, 26 (15.4% of the total cohort) were discharged on oral antibiotics, most commonly for 7 days, using either amoxicillin-clavulanate or ciprofloxacin plus metronidazole. Among patients who received more than one dose, the mean duration of antibiotic therapy was 3 days (range, 1-11 days). One patient who received 11 days of oral antibiotics following discharge had blood cultures positive for *Staphylococcus epidermidis* in two sets; no repeated blood cultures were obtained.

Twenty subjects (12%) had a documented penicillin allergy in their medical record. Among patients with a documented penicillin allergy, 40% received beta-lactam antibiotics, including piperacillin-tazobactam, ceftriaxone, cefazolin, or ceftriaxone plus metronidazole, regardless of the reaction type. The remaining 60% received alternative regimens, including a fluoroquinolone plus metronidazole, ertapenem, or clindamycin. Alignment between antibiotic selection and guideline recommendations among patients with a documented penicillin allergy is presented in Table 3.

The mean acquisition cost of antibiotics was $9.30 (range, $0.12-$50.30). At this institution, the cost per vial was $2.37 for piperacillin-tazobactam and $3.31 for cefazolin. Patients who received piperacillin-tazobactam frequently received multiple doses, whereas patients who received cefazolin typically received a single pre-operative dose. A formal pharmacoeconomic analysis was not conducted in this stuFactors associated with antibiotic prescribing differed by prescriber type. Figure 1 illustrates differences in pre-operative antibiotic selection across prescriber groups. Emergency medicine physicians prescribed piperacillin-tazobactam more frequently than internal medicine residents (23.1% vs. 8.3%). In contrast, certified registered nurse anesthetists and anesthesiologists most commonly prescribed cefazolin (19% and 9%, respectively). General surgeons demonstrated greater variability in antibiotic selection, including piperacillin-tazobactam (8%), cefoxitin (1%), and ertapenem (2%). Orders from nurse

Table 2. Antibiotics Received During Hospital Stay of Appendectomy and Cholecystectomy

Antibiotic Agents Received (n=169)	
Pip/Tazo — no. (%)	92 (54.4)
Cefazolin — no. (%)	48 (28.4)
Cefoxitin — no. (%)	6 (3.6)
Ceftriaxone + metronidazole — no. (%)	4 (2.4)
Ertapenem — no. (%)	6 (3.6)
Other — no. (%)	13 (7.7)
Extended beyond one dose — no. (%)	84 (49.7)
Total doses of antibiotic received, mean ± SD (range)	4 ± 6.31 (1-57)
Duration of therapy of total antibiotic received, mean ± SD (range)	3 ± 2 (1-11)

practitioners (5%), physician assistants (0.6%), hospitalists (0.6%), and obstetrician/gynecologists (0.6%) were less frequent overall. However, when antibiotics were prescribed by these providers, piperacillin-tazobactam was most commonly selected.

Discussion

This retrospective observational study found that the alignment of pre-operative antibiotic prescribing with guideline-recommended regimens was relatively low for appendectomies (12.5%) and cholecystectomies (58.4%) at a community hospital in West Texas. Despite the recommendation to use cefazolin plus metronidazole for appendectomies, no patient received this therapy, and the broad-spectrum antibiotic piperacillin-tazobactam was the most frequently used antibiotic. Notably, the susceptibility rate for E. coli to cefazolin has declined in recent years, with a susceptibility rate of 72% using the local antibiogram as of 2024. It's now low enough that cefazolin should not be recommended as first-line for intra-abdominal procedures or infections. Instead, cefoxitin, cefuroxime, or ceftriaxone plus metronidazole should be recommended due to high susceptibility (> 90%). The low selection of cefazolin plus metronidazole could be due to the resistance rate at our facility. However, broad-spectrum antibiotics were still used rather than simply using another cephalosporin. Thus, the problem remains. Ertapenem, a broad-spectrum carbapenem, is recommended for complicated appendectomy cases such as intra-abdominal infections, none of which had documented complications, indicating that broad-spectrum therapy was used in the absence of documented complications. While ertapenem is an appropriate option for complicated appendicitis, its use in uncomplicated cases may present an opportunity for antimicrobial stewardship intervention.[10] While guideline-recommended therapy was more commonly followed for cholecystectomies (cefazolin monotherapy), rates of guideline adherence were still suboptimal based on established surgical antimicrobial prophylaxis guidelines (e.g., ASHP/IDSA/SIS/SHEA).[2,3]

Our findings are similar to those from previous research. In a multisite quality improvement project at 17 surgical sites ranging from a small 15-bed critical access hospital to a large 1,265-bed quaternary care center, a multi-step intervention was implemented to decrease the use of piperacillin-tazobactam for treating uncomplicated acute appendicitis without increasing surgical site infections.[8] This quality improvement study was similar to ours in that it was performed retrospectively through review of Electronic Health Records (EHR), included uncomplicated acute appendicitis, and used piperacillin-tazobactam as the commonly prescribed antibiotic. In this study, the authors implemented two quality improvement components. The first was updating electronic health record orders to promote preoperative administration of narrow-spectrum antibiotics and creating an antibiotic panel specifically for appendicitis, with ceftriaxone/metronidazole as

the default regimen. Second, they educated surgeons and emergency department clinicians about selecting appropriate antibiotic therapy for acute appendicitis through a virtual 30-minute education session focused on antibiotic stewardship. Through this multi-pronged approach, they were able to significantly decrease the use of broad-spectrum piperacillin-tazobactom use by approximately 30% (51.4% preintervention period vs 20.1% postintervention period, $P < 0.001$), with no significant increase in surgical site infections.

To our knowledge, there are no quality improvement studies evaluating the optimization of pre-operative antibiotics in patients undergoing cholecystectomy. However, most studies available on cholecystectomy focused on whether prophylactic antibiotics reduce the risk of surgical site infection. In a retrospective quality improvement study testing the efficacy of preoperative antibiotics before cholecystectomy at a single tertiary academic institution, the incidence of surgical site infections was compared between those who received preoperative antibiotics and those who did not.[11] The study found that preoperative antibiotics for elective cholecystectomy were not beneficial, though patients with co-morbidities that are known to predispose to surgical site infection were included in mild cases. However, the efficacy of preoperative in high-risk patients remains unanswered.[11] On the other hand, a systematic review assessing the effects of preoperative antibiotics versus placebo or no preoperative antibiotics found insufficient evidence to support or refute the use of preoperative antibiotics to reduce surgical site infections.[12]

Regarding the duration of therapy, approximately half of the patients received more than one dose with an average duration of three days ranging from one to eleven days of either pre-operative or post-operative antibiotics. In some cases, patients who received multiple doses before surgery received them earlier than 60 minutes before the procedure, which may explain why an additional pre-operative dose was administered. However, most cases involved receiving more than a single dose. One possible explanation is that when an antibiotic order is entered, it is automatically set for a seven-day course unless the order is modified. This may have contributed to the administration of multiple doses. Similarly, the reasons for continuation of antibiotics postoperatively are unclear; however, this may reflect transitions in care, whereby antibiotics initiated by one prescriber are continued by subsequent providers after transfer to the inpatient ward. Additionally, in one case, prolonged antibiotic therapy was prescribed after two blood cultures tested positive for *Staphylococcus epidermidis*, a coagulase-negative staphylococci that is a common blood culture contaminant, without repeat cultures; therefore, this was not true bacteremia. This may have led to unnecessary continuation of antibiotics and highlights the importance of careful interpretation of blood culture results to prevent overtreatment.

Patients with reported penicillin allergies showed variability in antibiotic prescribing. Reported reactions included throat swelling, loss of consciousness, rash, hives, difficulty breathing, or unspecified reactions. In our study, there was no association between the documented penicillin allergy and adherence to guideline-recommended therapy. Nearly half of the patients received beta-lactam antibiotics despite documented reactions, while the rest were prescribed fluoroquinolone plus metronidazole, ertapenem, or clindamycin. Among these patients, some had severe allergy symptoms, such as “closed throat” documented in their chart prior to receiving preoperative antibiotics, while others had unknown allergic reactions documented. The lack of correlation suggests that antibiotic prescribing in patients with a documented allergy may depend on the prescriber's judgment.[13] Penicillin allergies are often mislabeled, which may lead to the use of less-preferred alternative antibiotics, contributing to antibiotic resistance and resulting in adverse outcomes. Penicillin allergy is a public health issue; however, less than 10% of reported penicillin allergy is confirmed by formal testing.[13] Various clinical decision-making tools for penicillin allergy have been developed to guide antibiotic selection and delabeling strategies. However, some of these tools are limited by their

generalizability and lack of external validation. PEN-FAST is a clinical decision-making tool with a high negative predictive value that can be used to identify patients with low-risk penicillin allergy who do not require skin testing prior to oral penicillin challenge.[14] It is a user-friendly tool that has been successfully validated, with a negative predictive value of 93% to 100% in identifying patients with a low-risk history of penicillin allergy who can safely discontinue antibiotics and be unlabeled.

In addition to concerns regarding unnecessary antibiotic exposure and adverse effects associated with broad-spectrum antibiotic use, there are also fiscal concerns. While a formal pharmacoeconomic analysis was not conducted in this study, the total costs related to antibiotic therapy, including preparation and infusion supplies, nursing and pharmacy labor, and downstream costs, were likely much higher for patients who received piperacillin-tazobactam. In addition, the potential morbidity associated with broad-spectrum antibiotic use and development of *C difficile* infections may contribute to increased costs and adverse effects. According to CDC Antimicrobial Stewardship's four core elements guidelines, “Action”—the implementation of interventions to optimize antibiotic use—is essential for reducing costs.[15] These findings reinforce the importance of strengthening antimicrobial stewardship practices to promote guideline-recommended therapy and cost-effective antibiotics.

The variability of antibiotic choice by prescriber type suggests that antibiotic selection is influenced not only by provider specialty but also by the clinical setting in which prescribing occurs. Emergency medicine physicians more frequently prescribed broader empiric coverage, whereas certified registered nurse anesthetists and anesthesiologists commonly use cefazolin in alignment with guideline-recommended therapy for cholecystectomy. Surgeons demonstrate mixed prescribing patterns, likely reflecting intraoperative decision-making and variability in practice habits. While prescribing volumes were lower among other provider groups, the predominance of piperacillin-tazobactam across multiple settings highlights a consistent tendency toward broad-spectrum use.

Limitations

While our study demonstrates significant issues with guideline-concordant prescribing, there are limitations. First, the sample size was relatively small and from a single center. However, our study in a West Texas community-based hospital had similar findings as other studies.[8] Additionally, there were no data on the provider’s decision-making process when choosing antibiotics. Unmeasured confounders include patients’ comorbidities such as diabetes, which increases the risk of infection due to poor wound healing; obesity, related to poor tissue perfusion and a higher inoculum; previous infectious diseases and prior antibiotic exposure, which raise the likelihood of resistant organisms; immunosuppression, potentially increasing the infection risk; liver failure, due to a higher risk of surgical site infection; and tobacco use, which can impair wound healing, cannot be adequately assessed. The timing of antibiotic administration is also an important confounder, with the recommended preoperative timing being 60 minutes prior to the procedure. If patients do not receive the antibiotic within this timeframe, it may result in administering more than the

Table 3. Chi-Square Test for Alignment with Guideline-Recommended Therapy and Penicillin Allergy (n=169)

Alignment with Guidelines	Penicillin Allergy n (%)			P-value
	Yes	No	Total	
Yes	8 (40)	54 (36)	62 (37)	0.807
No	12 (60)	95 (64)	107 (63)	
Total	20 (100)	149 (100)	169 (100)	

recommended dose. Literature supports administering antibiotics at least 30 minutes but no more than 60 minutes before skin incision for optimal preoperative administration.[15] Additional limitations are the possibility of other unmeasured cofounders, such as surgical technique, including maintaining sterility to avoid the need for additional antibiotics, and the provider's experience, such as confidence in using broad-spectrum antibiotics for broader coverage to prevent complications.

Conclusion

The frequency of alignment of pre-operative antibiotic prescribing with guideline-recommended regimens for appendectomy and cholecystectomy in a community-based West Texas hospital was low, with lower alignment for appendectomy than for cholecystectomy. Results from this study suggest several challenges related to the appropriate use of pre-operative antibiotics, including the type of antibiotics, duration of therapy, considerations for patients with penicillin allergy, and prescriber patterns in antibiotic choice. Targeted antimicrobial stewardship interventions, particularly standardized order-sets and prescriber education, represent actionable opportunities to improve guideline-concordant prescribing.

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