Physical Education, Health and Social Sciences

https://journal-of-social-education.org

E-ISSN: 2958-5996

P-ISSN: 2958-5988

Frequency and Clinical Determinants of Surgical Site Infection Following Open Thoracotomy at a Tertiary Care Thoracic Surgery Center in Lahore, Pakistan

Naeem Akhtar[1], Muhammad Riaz[2], Nadeem Sharif[3]*, Waqas Ahmad[4], Attique Ahmed[5]

[1] Department of Allied Health Sciences, University of Okara, Okara, Pakistan
[2] Department of Microbiology and Molecular Genetics, University of Okara, Okara, Pakistan
[3] Department of Pathology, Isfandyar Bukhari District Hospital Attock, Punjab, Pakistan
Corresponding Author: Email: nadeemsharif59@gmail.com
[4] Department of Allied Health Sciences, Lahore University of Biological & Applied Sciences (UBAS), Lahore, Pakistan
[5] Institute of Biochemistry and Biotechnology, University of Veterinary and Animal Sciences Lahore

DOI: https://doi.org/10.63163/jpehss.v3i4.1770

Abstract

Open thoracotomy remains an indispensable surgical approach for complex pleuropulmonary and mediastinal pathologies, including chronic empyema decortication and pulmonary resection, particularly in high-burden tuberculosis settings. However, postoperative surgical site infection (SSI) contributes substantially to patient morbidity, prolonged hospitalization, and healthcare expenditure. To determine the frequency of postoperative surgical site infection and evaluate associated operative, wound classification, and antimicrobial prophylaxis characteristics among patients undergoing open thoracotomy at a tertiary care thoracic surgery referral center. This descriptive observational study was conducted at tertiary care hospital of Lahore, over a five-month period from September 2024 to January 2025. A total of 150 consecutive patients who underwent open thoracotomy were enrolled. Data regarding patient sex, surgical priority (elective vs. emergency), thoracotomy incision approach (posterolateral vs. anterolateral), Centers for Disease Control and Prevention (CDC) surgical wound classification, preoperative antimicrobial prophylaxis (administration status, pre-incision timing interval, and cephalosporin generation), postoperative local wound swelling, and surgical site infection were recorded using a standardized clinical proforma. Statistical analysis was performed using SPSS version 16.0, applying Pearson's Chi-square and Fisher's exact tests for categorical comparisons. Among the 150 patients, 94 (62.67%) were male and 56 (37.33%) were female (male-to-female ratio, 1.68:1). Nearly all procedures were elective (n = 149, 99.33%), with only 1 (0.67%) emergency thoracotomy. Posterolateral thoracotomy was utilized in 120 (80.00%) patients and anterolateral thoracotomy in 30 (20.00%) patients. Preoperative antimicrobial prophylaxis was documented in 108 (72.00%) patients - predominantly third-generation cephalosporins (n = 80, 53.33%), followed by second-generation (n = 19, 12.67%) and fourth-generation (n = 9, 6.00%) cephalosporins - whereas 42 (28.00%) patients had no documented prophylaxis (8.00% none administered; 20.00% unknown). Only 23 (15.33%) patients received prophylaxis within the optimal 1-hour pre-incision window. Per CDC wound classification, 128 (85.33%) procedures were Class I (clean), 18 (12.00%) were Class II (clean-contaminated), and 4 (2.67%) were Class III (contaminated). Postoperative wound infection (SSI) was identified in 7 (4.67%) patients (95% CI: 2.28%-9.31%), including 6 (4.00%)

patients with culture-positive purulent discharge. SSI incidence did not differ significantly between anterolateral (2/30, 6.67%) and posterolateral (5/120, 4.17%) approaches (p = 0.627). However, SSI was strongly associated with CDC wound classification (0.0% [0/128] in clean, 16.67% [3/18] in clean-contaminated, and 100.0% [4/4] in contaminated wounds; p < 0.001) and local wound swelling (50.0% [3/6] vs. 2.78% [4/144]; Odds Ratio = 35.0; p < 0.001). The overall incidence of postoperative surgical site infection following open thoracotomy was 4.67% (4.00% culture-confirmed purulent subset), which compares favorably with international cardiothoracic benchmarks. Because all infections occurred in clean-contaminated and contaminated wounds and optimal pre-incision antibiotic timing (<=1 hour) was achieved in only 15.33% of cases, institutional standardization of surgical antimicrobial prophylaxis protocols and targeted wound surveillance in non-clean thoracotomies are warranted.

Keywords: Thoracotomy; Surgical Site Infection; Pleural Decortication; Antimicrobial Prophylaxis; CDC Wound Classification; Thoracic Surgery.

Introduction

Thoracotomy - the surgical incision into the pleural space of the chest wall to gain operative access to the lungs, pleura, heart, esophagus, thoracic aorta, or anterior spine - remains a foundational procedure in cardiothoracic and general thoracic surgery [1,2]. Depending on the anatomical target and surgical indication, thoracic access is achieved via posterolateral, anterolateral, axillary, or bilateral anterolateral ('clamshell') incisions [3,4]. While video-assisted thoracoscopic surgery (VATS) has expanded in high-income settings, open posterolateral and anterolateral thoracotomies remain the primary operative modalities in many tertiary centers across South Asia for managing advanced pleuropulmonary infections, chronic tuberculous empyema requiring pleural decortication, bronchiectasis, hydatid lung disease, and intrathoracic neoplasms [5,6].

Despite advances in perioperative care, open thoracotomy carries a substantial risk of postoperative morbidity, including persistent air leaks, atelectasis, pneumonia, acute respiratory distress syndrome (ARDS), hemorrhage, post-thoracotomy pain syndrome, and surgical site infection (SSI) [6-8]. Surgical site infections represent one of the most frequent healthcare-associated infections (HAIs), accounting for approximately 10% to 30% of all nosocomial infections worldwide [9,10]. While overall SSI incidence across general inpatient surgical procedures averages 1.9% to 5.0% in high-income surveillance networks [10,11], incidence varies considerably by surgical specialty, ranging from 3% to 36% in gastrointestinal surgery and 5% to 19% in cardiothoracic procedures [9,12,13].

In thoracic surgery, postoperative wound infections range from superficial incisional cellulitis and subcutaneous abscess formation to deep musculo-fascial dehiscence, osteomyelitis of the ribs, and post-thoracotomy empyema [14-16]. Separation or dehiscence of a thoracotomy incision is a serious complication triggered by local tissue infection, compromised chest wall vascularity, malnutrition, or mechanical failure of suture closure under respiratory excursion [14,17,18]. Management of deep thoracotomy wound sepsis frequently necessitates prolonged hospitalization, repeated mechanical debridement, povidone-iodine or negative-pressure wound dressings, or secondary myocutaneous flap reconstruction [15,16,19].

Multiple perioperative factors influence the risk of post-thoracotomy SSI. The Centers for Disease Control and Prevention (CDC) surgical wound classification - which stratifies operations into Clean (Class I), Clean-Contaminated (Class II), Contaminated (Class III), and Dirty-Infected (Class IV) based on the intrinsic microbial load of the operative field - is a primary determinant of postoperative wound sepsis [10,20]. Equally critical is the appropriate administration of preoperative surgical antimicrobial prophylaxis (SAP). International clinical practice guidelines

stipulate that prophylactic parenteral antibiotics (typically first- or second-generation cephalosporins) should be infused within 60 minutes prior to skin incision to ensure bactericidal tissue concentrations at the moment of microbial contamination [20,21].

In Pakistan and neighboring developing countries, data specifically evaluating the incidence of post-thoracotomy SSI, adherence to preoperative antibiotic timing guidelines, and stratified risk across CDC wound classes remain limited. Therefore, the present study was conducted to determine the frequency of postoperative surgical site infection and examine its clinical, operative, and antimicrobial prophylaxis correlates among patients undergoing open thoracotomy at tertiary care hospital of Lahore.

Materials and Methods

Study Design, Setting, and Duration

This descriptive observational study (case series) was conducted at tertiary care hospital of Lahore, a major tertiary care referral center for pulmonary and cardiothoracic diseases. The study was carried out over a five-month period from September 2024 to January 2025 following approval from the institutional research review committee.

Sample Size and Eligibility Criteria

A consecutive sample of N = 150 patients undergoing open thoracotomy during the study period was enrolled. Inclusion criteria comprised all male and female patients admitted to the Department of Thoracic Surgery who underwent elective or emergency open thoracotomy (including pleural decortication, pulmonary resection, and related open intrathoracic procedures) and completed postoperative inpatient and 30-day outpatient clinic follow-up. Patients who underwent closed tube thoracostomy alone, minimally invasive diagnostic procedures without thoracotomy, or primary thoracic surgery at an outside facility prior to referral were excluded.

Operational Definitions

Surgical Site Infection (SSI): Defined in accordance with CDC National Healthcare Safety Network (NHSN) criteria as an infection occurring at or near the thoracotomy incision within 30 days of the operative procedure, characterized by at least one of the following: (a) purulent drainage from the superficial or deep incision; (b) organisms isolated from an aseptically obtained culture of fluid or tissue from the incision; or (c) clinical signs of local infection (localized swelling, tenderness/pain, erythema, or heat) accompanied by deliberate opening of the wound by the thoracic surgeon or a clinical diagnosis of wound infection [10,20].

Surgical Wound Classification: Wounds were categorized intraoperatively by the surgical team per CDC guidelines into three classes observed in this cohort: (1) Class I (Clean): An uninfected operative wound in which no inflammation is encountered and the respiratory, alimentary, or urogenital tracts are not entered; (2) Class II (Clean-Contaminated): An operative wound in which the respiratory or alimentary tract is entered under controlled conditions and without unusual contamination; and (3) Class III (Contaminated): Operations with major breaks in sterile technique, gross spillage, or incisions encountering acute, non-purulent or chronic pleural inflammation/empyema during decortication.

Data Collection Procedure

A structured clinical data collection proforma (Appendix Table A1) was completed for each patient through direct bedside evaluation, review of anesthesia and operative records, and microbiology laboratory culture reports. Recorded variables included patient demographics (age, sex), operative urgency (elective vs. emergency surgery), surgical incision approach (posterolateral vs.

anterolateral thoracotomy), CDC wound classification (clean, clean-contaminated, or contaminated), preoperative antimicrobial prophylaxis status (administered, not administered, or unknown/unrecorded), interval between antibiotic infusion and skin incision (1 hour, 2 hours, 3 hours, or >3 hours prior to surgery), cephalosporin generation administered (second-, third-, or fourth-generation), and postoperative clinical wound outcomes (fever, local swelling, pain, wound dehiscence, purulent discharge, and pus culture positivity).

Statistical Analysis

Data entry and statistical analyses were performed using IBM SPSS Statistics for Windows, Version 16.0 (SPSS Inc., Chicago, IL, USA). Categorical variables were summarized as frequencies (n) and percentages (%), accompanied by 95% Wilson score confidence intervals (95% CI) for primary prevalence estimates. Bivariate associations between clinical/operative factors (incision approach, CDC wound classification, and local wound swelling) and postoperative SSI were evaluated using Pearson's Chi-square (X2) test or two-tailed Fisher's exact test where expected cell counts were <5. Odds ratios (OR) with 95% confidence intervals and diagnostic performance metrics (sensitivity, specificity, positive predictive value [PPV], and negative predictive value [NPV]) were calculated for clinical wound swelling. A two-tailed p-value < 0.05 was considered statistically significant.

Results

Baseline Demographic and Operative Characteristics

A total of 150 patients who underwent open thoracotomy were evaluated during the study period. Of these, 94 (62.67%) were male and 56 (37.33%) were female, corresponding to a male-to-female ratio of 1.68:1 (Table 1; Figure 1A). With respect to operative urgency, the vast majority of procedures were performed on an elective basis (n = 149, 99.33%), whereas only 1 (0.67%) procedure was performed as an emergency thoracotomy (Figure 1B).

Regarding the anatomical approach, posterolateral thoracotomy was the predominant incision utilized in 120 (80.00%) patients, while anterolateral thoracotomy was performed in 30 (20.00%) patients (4:1 ratio; Figure 1B). Stratification of the cohort by CDC surgical wound classification demonstrated that 128 (85.33%) operations were classified as Class I (Clean), 18 (12.00%) as Class II (Clean-Contaminated), and 4 (2.67%) as Class III (Contaminated) (Table 1; Figure 1C).

Table 1. *Baseline demographic and operative characteristics of patients undergoing open thoracotomy (N = 150).*

Characteristic / Category	Frequency (n)	Percentage (%)	95% Confidence Interval
Sex Distribution			
Male	94	62.67%	54.70% - 70.00%
Female	56	37.33%	30.00% - 45.30%
Surgical Priority (Urgency)			
Elective Thoracotomy	149	99.33%	96.32% - 99.88%
Emergency Thoracotomy	1	0.67%	0.12% - 3.68%

Characteristic / Category	Frequency (n)	Percentage (%)	95% Confidence Interval
Thoracotomy Incision Approach			
Posterolateral Incision	120	80.00%	72.89% - 85.62%
Anterolateral Incision	30	20.00%	14.38% - 27.11%
CDC Surgical Wound Classification			
Class I: Clean	128	85.33%	78.79% - 90.11%
Class II: Clean-Contaminated	18	12.00%	7.73% - 18.16%
Class III: Contaminated	4	2.67%	1.04% - 6.65%
Total Study Cohort	**150**	**100.00%**	-

Abbreviations: CDC, Centers for Disease Control and Prevention; CI, Wilson score confidence interval.

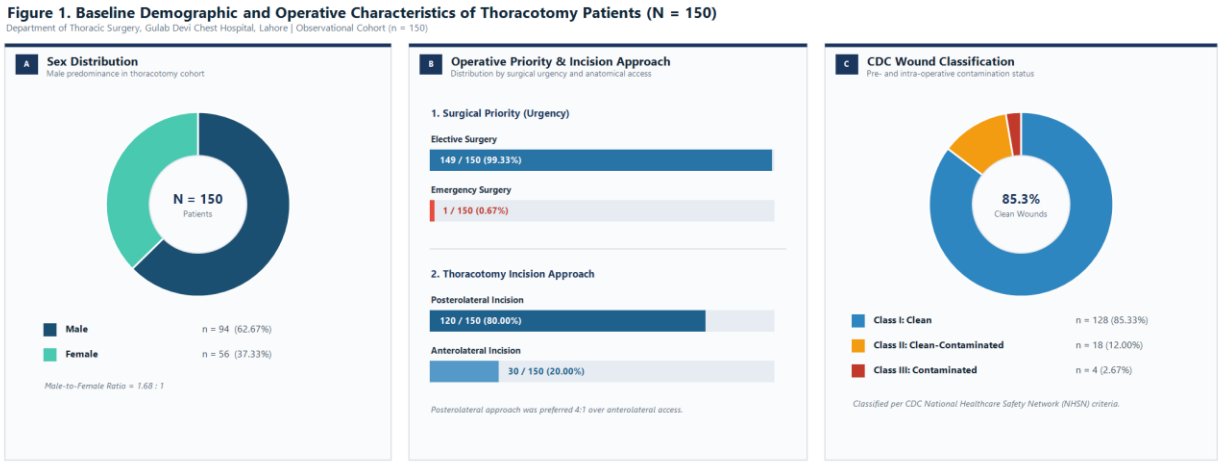

Figure 1. *Baseline Demographic and Operative Characteristics of Thoracotomy Patients (N = 150). (A) Sex distribution demonstrating male predominance (62.67% vs. 37.33%). (B) Proportions of elective versus emergency surgical priority and posterolateral versus anterolateral thoracotomy access. (C) Distribution of surgical wounds according to CDC National Healthcare Safety Network (NHSN) wound contamination classes.*

Preoperative Antimicrobial Prophylaxis Profile

Evaluation of perioperative medication records revealed that 108 (72.00%) patients had documented administration of preoperative antimicrobial prophylaxis prior to thoracotomy, 12 (8.00%) patients did not receive preoperative antibiotic prophylaxis, and 30 (20.00%) patients had no recorded history of prophylaxis in their surgical chart (combined non-documented/no prophylaxis group: n = 42, 28.00%) (Table 2; Figure 2A).

Analysis of the timing interval between antibiotic infusion and skin incision showed substantial variability (Figure 2B). Only 23 (15.33%) patients received antimicrobial prophylaxis within 1

hour prior to incision, while 28 (18.67%) received it 2 hours before surgery, 22 (14.67%) received it 3 hours before surgery, and 35 (23.33%) received prophylaxis more than 3 hours prior to incision. Among the 108 patients who received prophylaxis, 51 (47.22% of treated patients; 34.00% of total cohort) received their dose within 2 hours of incision, whereas 57 (52.78% of treated patients; 38.00% of total cohort) experienced delayed incisions (>2 hours after antibiotic administration).

With respect to antimicrobial class selection, cephalosporins were exclusively utilized among patients receiving prophylaxis (Table 2; Figure 2C). Third-generation cephalosporins were administered to 80 (53.33% of total cohort; 74.07% of prophylaxed patients) patients, second-generation cephalosporins to 19 (12.67% of total cohort; 17.59% of prophylaxed patients) patients, and fourth-generation cephalosporins to 9 (6.00% of total cohort; 8.33% of prophylaxed patients) patients.

Table 2. *Preoperative antimicrobial prophylaxis coverage, timing prior to incision, and cephalosporin class selection (N = 150).*

Prophylaxis Parameter / Category	Frequency (n)	Percentage of Total (N = 150)	Percentage of Treated (n = 108)
Prophylaxis Administration Status			
Administered (Documented Yes)	108	72.00%	100.00%
Not Administered (No)	12	8.00%	-
Unknown / Unrecorded History	30	20.00%	-
Pre-Incision Timing Interval			
1 Hour Prior to Incision (Optimal)	23	15.33%	21.30%
2 Hours Prior to Incision	28	18.67%	25.93%
3 Hours Prior to Incision	22	14.67%	20.37%
>3 Hours Prior to Incision	35	23.33%	32.41%
None / Unrecorded	42	28.00%	-
Cephalosporin Generation Utilized			
2nd-Generation Cephalosporin	19	12.67%	17.59%
3rd-Generation Cephalosporin	80	53.33%	74.07%

Prophylaxis Parameter / Category	Frequency (n)	Percentage of Total (N = 150)	Percentage of Treated (n = 108)
4th-Generation Cephalosporin	9	6.00%	8.33%
None / Unrecorded	42	28.00%	-
Total Study Cohort	**150**	**100.00%**	**-**

Note: The 42 (28.00%) patients in the None/Unrecorded category of timing and antibiotic generation represent the sum of patients who did not receive prophylaxis (n = 12, 8.00%) and those with unrecorded prophylaxis history (n = 30, 20.00%).

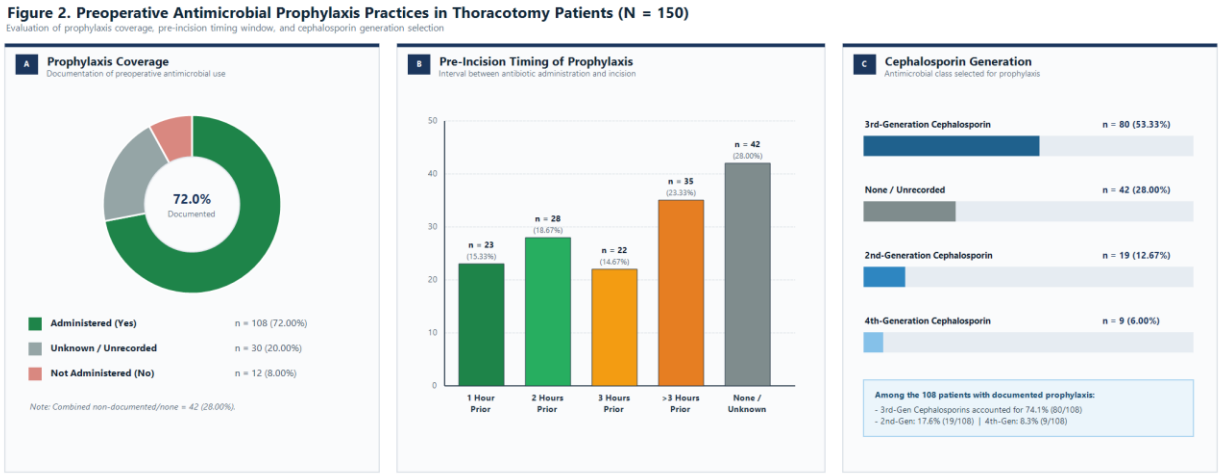

Figure 2. *Preoperative Antimicrobial Prophylaxis Practices in Thoracotomy Patients (N = 150). (A) Prophylaxis coverage status showing 72.00% documented administration. (B) Distribution of pre-incision antibiotic timing intervals across the cohort. (C) Breakdown of cephalosporin generations selected for surgical prophylaxis.*

Overall Prevalence of Postoperative Surgical Site Infection and Local Wound Swelling

Out of the 150 patients who underwent open thoracotomy, 7 (4.67%; 95% CI: 2.28%-9.31%) developed clinical postoperative surgical site infection (wound infection), while 143 (95.33%; 95% CI: 90.69%-97.72%) had uncomplicated wound healing without evidence of infection (Table 3; Figure 3A). Among the 7 patients with clinical wound infection, 6 (4.00% of total cohort) exhibited frank purulent discharge with positive microbiological pus cultures.

Postoperative local wound swelling at the thoracotomy incision site was observed in 6 (4.00%) patients, while 144 (96.00%) had no swelling (Figure 3B). Cross-tabulation of wound swelling with surgical site infection revealed a highly significant clinical association (Table 3; Figure 3C). Specifically, 3 (2.00% of total cohort) patients had both wound infection and swelling, 4 (2.67%) had wound infection without swelling, 3 (2.00%) had benign postoperative swelling without wound infection, and 140 (93.33%) had neither swelling nor SSI. Consequently, the incidence of SSI was 50.00% (3/6) among patients presenting with local wound swelling compared to 2.78% (4/144) among those without swelling (Fisher's exact test, $p < 0.001$; Odds Ratio = 35.0, 95% CI: 5.43-225.71). As a clinical indicator of SSI, local wound swelling demonstrated a specificity of 97.90% (140/143) and a negative predictive value of 97.22% (140/144), though sensitivity was 42.86% (3/7).

Table 3. *Overall prevalence of postoperative surgical site infection (SSI) and contingency analysis with local wound swelling (N = 150).*

Postoperative Wound Parameter	SSI Present (n = 7)	SSI Absent (n = 143)	Total Cohort (N = 150)	Subgroup SSI Rate (%)	p-value
Local Wound Swelling Status					
Swelling Present (Yes)	3 (2.00%)	3 (2.00%)	6 (4.00%)	50.00% (3/6)	< 0.001*
Swelling Absent (No)	4 (2.67%)	140 (93.33%)	144 (96.00%)	2.78% (4/144)	
Overall Wound Infection Status					
Clinical SSI (All Cases)	7 (4.67%)	143 (95.33%)	150 (100.0%)	4.67% (7/150)	-
Culture-Positive Pus Subset	6 (4.00%)	144 (96.00%)	150 (100.0%)	4.00% (6/150)	-

**Two-tailed Fisher's exact test (p = 0.00097; Pearson Chi-square = 28.85, p < 0.001). Percentages in parentheses in columns 2-4 represent proportions of the total cohort (N = 150). Odds Ratio for wound swelling = 35.00 (95% CI: 5.43 - 225.71).*

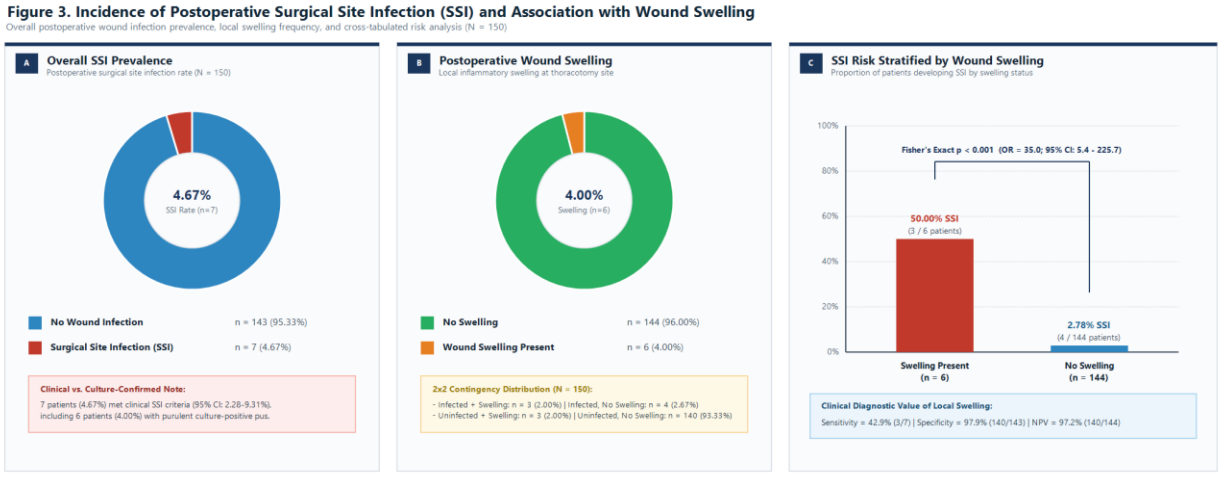

Figure 3. *Incidence of Postoperative Surgical Site Infection (SSI) and Association with Wound Swelling (N = 150). (A) Overall postoperative SSI prevalence (4.67% clinical SSI; 4.00% culture-confirmed purulent subset). (B) Frequency of postoperative incisional swelling (4.00%). (C) Stratified SSI risk comparing patients with and without local wound swelling (50.00% vs. 2.78%; Fisher's exact p < 0.001).*

Stratification of Surgical Site Infection by Incision Approach and CDC Wound Classification

To evaluate surgical determinants of postoperative wound infection, SSI frequency was stratified across thoracotomy incision approaches and CDC surgical wound contamination classes (Table 4; Figure 4).

Among the 30 patients who underwent anterolateral thoracotomy, 2 (1.33% of total cohort; 6.67% within subgroup) developed postoperative SSI and 28 (18.67% of total cohort; 93.33% within subgroup) remained uninfected. Among the 120 patients who underwent posterolateral thoracotomy, 5 (3.33% of total cohort; 4.17% within subgroup) developed SSI and 115 (76.67% of total cohort; 95.83% within subgroup) were uninfected (Figure 4A). The difference in SSI incidence between anterolateral (6.67%) and posterolateral (4.17%) incisions was not statistically significant (Chi-square = 0.336, Fisher's exact p = 0.627; Odds Ratio = 1.64, 95% CI: 0.30-8.91).

In contrast, stratification by CDC surgical wound classification revealed a profound and statistically significant gradient in SSI risk (Chi-square = 104.93, df = 2, $p < 0.001$; Table 4; Figure 4B). Among the 128 patients with Class I (Clean) thoracotomy wounds, 0 (0.00%) developed a surgical site infection. Among the 18 patients with Class II (Clean-Contaminated) wounds, 3 (2.00% of total cohort; 16.67% within subgroup) developed SSI and 15 (10.00% of total cohort; 83.33% within subgroup) healed without infection. Notably, all 4 (2.67% of total cohort; 100.00% within subgroup) patients with Class III (Contaminated) wounds developed postoperative SSI. Thus, 100% (7/7) of all surgical site infections in this cohort occurred in non-clean (Class II and Class III) thoracic procedures.

Table 4. *Stratification of postoperative surgical site infection (SSI) by thoracotomy incision approach and CDC surgical wound classification (N = 150).*

Surgical Variable / Subgroup	Total Subgroup (n)	SSI Present n (% Total)	SSI Absent n (% Total)	Subgroup SSI Rate (%)	Statistical Test & p-value
Thoracotomy Incision Approach					
Anterolateral Incision	30	2 (1.33%)	28 (18.67%)	6.67% (2/30)	X2 = 0.336
Posterolateral Incision	120	5 (3.33%)	115 (76.67%)	4.17% (5/120)	p = 0.627 (NS)
CDC Wound Classification					
Class I: Clean	128	0 (0.00%)	128 (85.33%)	0.00% (0/128)	X2 = 104.93
Class II: Clean-Contaminated	18	3 (2.00%)	15 (10.00%)	16.67% (3/18)	df = 2
Class III: Contaminated	4	4 (2.67%)	0 (0.00%)	100.00% (4/4)	p < 0.001*

Surgical Variable / Subgroup	Total Subgroup (n)	SSI Present n (% Total)	SSI Absent n (% Total)	Subgroup SSI Rate (%)	Statistical Test & p-value
Total Study Cohort	**150**	**7 (4.67%)**	**143 (95.33%)**	**4.67% (7/150)**	-

**Statistically significant at p < 0.001 (Pearson's Chi-square test and Fisher-Freeman-Halton exact test). Abbreviations: CDC, Centers for Disease Control and Prevention; NS, not statistically significant; X2, Chi-square statistic.*

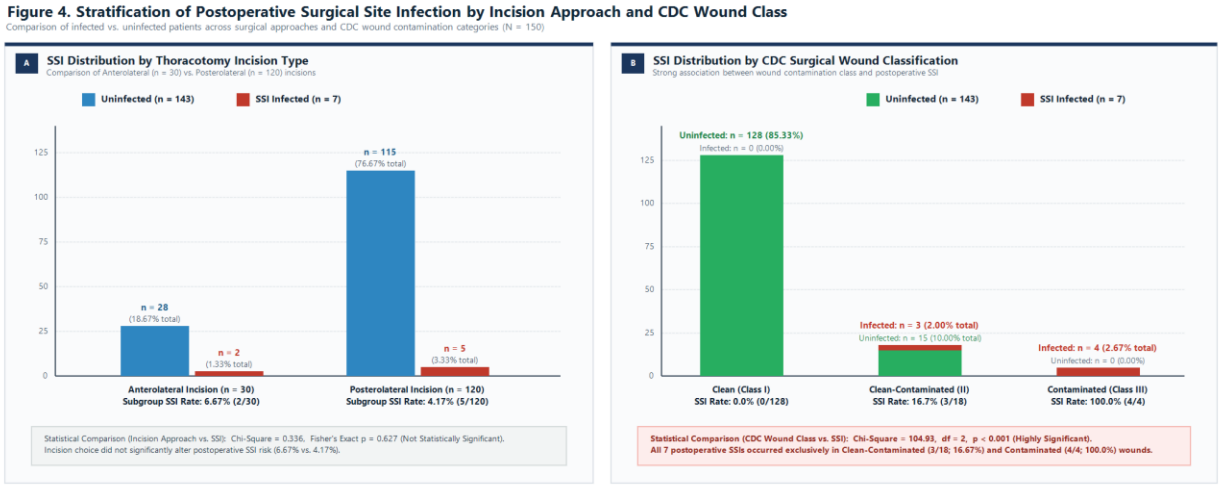

Figure 4. *Stratification of Postoperative Surgical Site Infection by Incision Approach and CDC Wound Class (N = 150). (A) Clustered bar chart comparing uninfected and SSI-infected cases across anterolateral (n = 30) and posterolateral (n = 120) incisions (p = 0.627). (B) Stacked bar chart demonstrating the concentration of all 7 postoperative SSIs within Clean-Contaminated (3/18; 16.67%) and Contaminated (4/4; 100.0%) wounds compared to Clean wounds (0/128; 0.0%) (p < 0.001).*

Discussion

Postoperative surgical site infection following open thoracotomy is a potentially devastating complication that can progress from superficial wound suppuration to deep chest wall dehiscence and pleural empyema, substantially increasing hospital length of stay and healthcare costs [9,14,15]. In the present observational study of 150 consecutive thoracotomy patients at tertiary care hospital of Lahore, the overall frequency of clinical surgical site infection was 4.67% (7/150), with 4.00% (6/150) exhibiting culture-positive purulent drainage. This incidence falls squarely within the classic acceptable surgical wound infection benchmark of 4% to 7% established by Cruse [22] and compares favorably with historical and contemporary series of open cardiothoracic procedures.

When contextualized against international surveillance literature, our observed SSI prevalence of 4.00% to 4.67% reflects solid perioperative infection control within a high-volume public tertiary thoracic unit in a lower-middle-income setting. In a landmark five-year prospective wound surveillance study of 20,193 operations by Olson et al. [23], baseline postoperative wound sepsis across surgical services was 4.2% - nearly identical to our cohort - before declining to 1.9% following the implementation of dedicated nurse-epidemiologist surveillance and monthly surgeon

feedback. Similarly, while the CDC National Healthcare Safety Network (NHSN) survey reported by Mu et al. [11] documented an aggregate inpatient SSI rate of 1.9% across 849,659 procedures in the United States, procedure-specific studies in cardiothoracic and general thoracic surgery consistently report higher SSI and wound complication rates ranging from 3.2% to 19.0% [9,12,13,17]. In an Indian cardiothoracic cohort examined by Bhatia et al. [13], postoperative infection rates ranged between 5% and 19%, underscoring that open chest wall procedures in South Asia face heightened infectious challenges due to late patient presentation and chronic infectious lung pathology.

A key finding of our study is the striking stratification of SSI risk by CDC surgical wound classification ($p < 0.001$). Notably, not a single case of postoperative SSI occurred among the 128 patients with Class I (Clean) thoracotomy wounds (0.0%). Conversely, SSI developed in 16.67% (3/18) of Class II (Clean-Contaminated) procedures and 100.0% (4/4) of Class III (Contaminated) procedures. At our institution, clean-contaminated and contaminated thoracotomies frequently involve bronchial transection or open pleural decortication for chronic parapneumonic or tuberculous empyema, where pre-existing intrapleural bacterial colonization inevitably contaminates the dissected intercostal and latissimus/serratus muscle planes during extraction of the fibrous pleural peel [5,15,16]. This observation aligns with prior thoracic series demonstrating that pre-existing pleural space infection and contaminated operative fields are the strongest independent predictors of post-thoracotomy wound infection and dehiscence [14-16].

In contrast, the choice of anatomical incision - posterolateral (80.00%) versus anterolateral (20.00%) thoracotomy - did not significantly influence SSI rates (4.17% vs. 6.67%; $p = 0.627$). Although posterolateral thoracotomy involves a longer incision and division of major chest wall musculature (latissimus dorsi and serratus anterior) compared to anterior approaches [3,4], rich collateral vascularization from the thoracoacromial, lateral thoracic, thoracodorsal, and posterior intercostal arteries promotes robust muscular healing provided that meticulous hemostasis and layered closure are achieved [7,17,18].

Importantly, our audit uncovered critical gaps in preoperative surgical antimicrobial prophylaxis (SAP) practices that warrant institutional quality improvement. First, 28.00% of patients had either no prophylaxis administered (8.00%) or lacked documentation of prophylaxis in their medical records (20.00%). Second, among patients who received prophylaxis, third-generation cephalosporins were predominantly prescribed (53.33% of the total cohort; 74.07% of treated patients), whereas second-generation cephalosporins accounted for only 12.67%. International surgical infection guidelines recommend first- or second-generation cephalosporins (such as cefazolin or cefuroxime) as first-line prophylaxis for thoracic procedures because they provide superior bactericidal activity against methicillin-susceptible Staphylococcus aureus and streptococci while minimizing the selection pressure for extended-spectrum beta-lactamase (ESBL)-producing Gram-negative bacilli [20,21]. Third, optimal pre-incision antibiotic timing - infusion within 60 minutes prior to skin incision - was achieved in only 15.33% (23/150) of patients, while 23.33% (35/150) received their antibiotic dose more than 3 hours before incision. Administration of beta-lactam antibiotics more than 2 to 3 hours before incision results in sub-therapeutic tissue concentrations at the time of skin incision and closure, significantly diminishing prophylactic efficacy [20,21].

Strengths and Limitations

This study provides structured prospective observational data from one of Pakistan's largest specialized thoracic surgery departments, capturing both clinical wound parameters and antibiotic timing intervals. Nevertheless, several limitations should be acknowledged. First, this was a single-center descriptive study with a modest sample size (N = 150) and a small absolute number of SSI

events (n = 7), which precluded multivariable logistic regression analysis. Second, patient-level systemic comorbidities known to influence wound healing - such as diabetes mellitus, body mass index (BMI), nutritional status (serum albumin), smoking history, chronic obstructive pulmonary disease (COPD), and total operative duration - were not quantitatively stratified in the dataset. Third, species-level microbiological distributions and antimicrobial susceptibility profiles of the isolated pathogens were not cross-tabulated against cephalosporin generations. Future multicenter prospective studies incorporating multivariable risk adjustment and 30-day post-discharge active surveillance are recommended.

Clinical Implications and Recommendations

Based on our findings, three actionable clinical interventions can further reduce post-thoracotomy SSI at tertiary centers: (1) enforcing the World Health Organization (WHO) Surgical Safety Checklist 'Time-Out' protocol in the operating theater so that prophylactic intravenous antibiotics are administered by the anesthesia team within 30 to 60 minutes prior to skin incision rather than on the inpatient ward several hours earlier; (2) standardizing institutional antibiotic stewardship toward first- or second-generation cephalosporins for clean elective thoracotomies while reserving targeted therapeutic regimens for contaminated empyema decortications; and (3) implementing wound protectors, antiseptic irrigation of the subcutaneous and muscle layers prior to closure, and close postoperative surveillance for Class II and Class III thoracotomy wounds.

Conclusion

In conclusion, the frequency of postoperative surgical site infection among patients undergoing open thoracotomy at tertiary care hospital of Lahore, was 4.67% (with 4.00% demonstrating culture-positive purulent wound infection). While clean thoracotomy procedures exhibited a 0.0% infection rate, all postoperative SSIs occurred in clean-contaminated (16.67%) and contaminated (100.0%) wounds, and local wound swelling was strongly predictive of underlying SSI ($p < 0.001$). Standardizing the timing and selection of preoperative antimicrobial prophylaxis and intensifying wound care protocols in contaminated thoracic procedures can substantially mitigate postoperative infectious morbidity.

Declarations

Ethical Approval and Consent to Participate: The study protocol was reviewed and approved by the Institutional Ethical Review Committee and Faculty of Allied Health Sciences, at tertiary care hospital of Lahore, Pakistan. Informed verbal and written consent was obtained from all participating patients prior to data collection.

Conflict of Interest: The authors declare that they have no competing financial or personal interests.

Funding Source: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

References

Larson RK, Evans BH. Eventration of the diaphragm. Am Rev Respir Dis. 1963;87:753-756.

Ashcraft KW, Holder TM. Pediatric Esophageal Surgery. Philadelphia: W.B. Saunders; 1986.

Ginsberg RJ. Alternative (muscle-sparing) incisions in thoracic surgery. Ann Thorac Surg. 1993;56(3):752-754.

Ashrafian H, Athanasiou T. Emergency prehospital on-scene thoracotomy: a novel method. Coll Antropol. 2010;34(4):1449-1452.

Yim AP. Paradigm shift in empyema management. Chest. 1999;115(3):611-612.

Fischer JE, Bland KI, Callery MP, eds. Mastery of Surgery. 5th ed. Philadelphia: Lippincott Williams & Wilkins; 2006.
Richardson JD, Franklin GA, Heffley S, Seligson D. Operative fixation of chest wall fractures: an underused procedure? Am Surg. 2007;73(6):591-597.
Attar S, Hankins JR, Turney SZ, Krasna MJ, McLaughlin JS. Paraplegia after thoracotomy: report of five cases and review of the literature. Ann Thorac Surg. 1995;59(6):1410-1416.
Leaper DJ, van Goor H, Reilly J, Petrosillo N, Geiss HK, Torres AJ, Berger A. Surgical site infection - a European perspective of incidence and economic burden. Int Wound J. 2004;1(4):247-273.
Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for Prevention of Surgical Site Infection, 1999. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. Infect Control Hosp Epidemiol. 1999;20(4):250-278.
Mu Y, Edwards JR, Horan TC, Berrios-Torres SI, Fridkin SK. Improving risk-adjusted measures of surgical site infection for the National Healthcare Safety Network. Infect Control Hosp Epidemiol. 2011;32(10):970-986.
Stahle E, Tammelin A, Bergstrom R, Hambreus A, Nystrom S, Hansson H. Sternal wound complications - incidence, microbiology and risk factors. Eur J Cardiothorac Surg. 1997;11(6):1146-1153.
Bhatia R, Pandey A, et al. Incidence and microbiological profile of surgical site infections in cardiothoracic surgery. Indian J Med Microbiol. 2003;21(3):180-185.
Welvaart WN, Oosterhuis JW, Paul MA. Negative pressure dressing for radiation-associated wound dehiscence after posterolateral thoracotomy. Interact Cardiovasc Thorac Surg. 2009;8(5):558-559.
Deschamps C, Allen MS, Miller DL, Nichols FC, Pairolero PC. Management of postpneumonectomy empyema and bronchopleural fistula. Semin Thorac Cardiovasc Surg. 2001;13(1):13-19.
Schneiter D, Grodzki T, Lardinois D, Kestenholz PB, Wojcik J, Kubisa B, et al. Accelerated treatment of postpneumonectomy empyema: a binational long-term study. J Thorac Cardiovasc Surg. 2008;136(1):179-185.
Ridderstolpe L, Gill H, Granfeldt H, Rutberg H. Superficial and deep sternal wound complications: incidence, risk factors and mortality. Eur J Cardiothorac Surg. 2001;20(6):1168-1175.
Spiliotis J, Tsiveriotis K, Datsis AD, Vaxevanidou A, Zacharis G, Giafis K, et al. Wound dehiscence: is still a problem in the 21st century: a retrospective study. World J Emerg Surg. 2009;4:12.
Jones G, Jurkiewicz MJ, Bostwick J, Wood R, Bried JT, Culbertson J, et al. Management of the infected median sternotomy wound with muscle flaps: the Emory 20-year experience. Ann Surg. 1997;225(6):766-776.
Bratzler DW, Dellinger EP, Olsen KM, Perl TM, Auwaerter PG, Bolon MK, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. Am J Health Syst Pharm. 2013;70(3):195-283.
Allegranzi B, Bischoff P, de Jonge S, Kubilay NZ, Zayed B, Gomes SM, et al. New WHO recommendations on preoperative measures for surgical site infection prevention: an evidence-based global perspective. Lancet Infect Dis. 2016;16(12):e276-e287.
Cruse PJ, Foord R. The epidemiology of wound infection: a 10-year prospective study of 62,939 wounds. Surg Clin North Am. 1980;60(1):27-40.
Olson M, O'Connor M, Schwartz ML. Surgical wound infections: a 5-year prospective study of 20,193 wounds at the Minneapolis VA Medical Center. Ann Surg. 1984;199(3):253-259.

El-Hag-Aly MA, Nashy MR. Double edge closure: a novel technique for reducing post-thoracotomy pain. A randomized control study. Interact Cardiovasc Thorac Surg. 2015;21(5):630-635.
Handy JR, Asaph JW, Skokan L, Reed CE, Koh S, Brooks G, et al. What happens to patients undergoing lung cancer surgery? Outcomes and quality of life before and after surgery. Chest. 2002;122(1):21-30.

Appendix: Clinical Data Collection Proforma

Appendix Table A1. *Standardized clinical proforma utilized for evaluating surgical site infection in thoracotomy patients at tertiary care hospital of Lahore.*

Section / Variable	Recorded Field / Response Categories
1. Patient Identification	Patient Name | Age (years) | Sex (Male / Female) | Hospital Reg. No. | Date of Operation
2. Primary Clinical Diagnosis	Preoperative and intraoperative pleuropulmonary / thoracic diagnosis
3. Surgical Priority	[ ] Elective Thoracotomy [ ] Emergency Thoracotomy
4. Thoracotomy Incision Type	[ ] Posterolateral Thoracotomy [ ] Anterolateral Thoracotomy
5. CDC Wound Classification	[ ] Class I: Clean [ ] Class II: Clean-Contaminated [ ] Class III: Contaminated
6. Preoperative Prophylaxis	[ ] Yes [ ] No [ ] Unknown / Unrecorded
7. Timing Prior to Incision	[ ] 1 hour before [ ] 2 hours before [ ] 3 hours before [ ] >3 hours before
8. Prophylactic Antibiotic Class	[ ] 2nd-Gen Cephalosporin [ ] 3rd-Gen Cephalosporin [ ] 4th-Gen Cephalosporin
9. Postoperative SSI Criteria	Fever (Yes/No) | Local Swelling (Yes/No) | Wound Dehiscence (Yes/No) | Pain (Yes/No) | Purulent Discharge (Yes/No) | Microbiological Culture Positive (Yes/No) | Final SSI Status (Yes/No)