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Bacteriological Investigation of Surgical Wound Infections and Their Clinical Implications

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Abstract: ***Background:*** *Surgical wound infections (SWIs) remain a significant cause of postoperative morbidity and prolonged hospital stay, often leading to increased healthcare costs and antimicrobial resistance.*
Aim of the Study: *The aim of this study was to identify the bacterial pathogens responsible for surgical wound infections, evaluate their antibiotic sensitivity patterns, and assess clinical implications in a tertiary care hospital setting.*
Methods: *A cross-sectional observational study was conducted at the Department of General Surgery, Prime Hospital, Dubai, UAE. The study spanned from January 2024 to December 2024. A total of 150 patients with clinically diagnosed postoperative wound infections were included using purposive sampling. Clinical and demographic data were collected through structured interviews and medical record reviews. Wound swabs were obtained for bacterial culture and antibiotic sensitivity testing. Statistical analysis was performed using SPSS version 26, with a p-value <0.05 considered statistically significant.*
Result: *Among 110 samples, 86 (78.2%) showed positive bacterial growth. The most frequently isolated organism was Staphylococcus aureus (37.2%), followed by Escherichia coli (22.1%), Pseudomonas aeruginosa (17.4%), and Klebsiella spp. (11.6%). Multidrug resistance was observed in 45.3% of isolates. Gram-positive bacteria were most sensitive to linezolid and vancomycin, while gram-negative organisms showed highest sensitivity to imipenem and amikacin. Prolonged duration of surgery, diabetes, and emergency procedures were significantly associated with SWIs ($p<0.05$).*
Conclusion: *S. aureus and gram-negative bacilli are predominant pathogens in surgical wound infections. High rates of multidrug resistance highlight the urgent need for routine surveillance, strict infection control measures, and rational antibiotic use to guide effective treatment strategies.*
Keywords: *Surgical wound infection, antibiotic resistance, Staphylococcus aureus, multidrug-resistant organisms, postoperative complications.*

Original Research Article

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INTRODUCTION

The human skin, the largest organ of the body, performs several critical physiological roles, including maintaining fluid and electrolyte homeostasis, regulating body temperature, supporting immune defense mechanisms, and acting as a protective barrier against harmful environmental agents such as pathogens [1]. When the skin's epithelial integrity is disrupted, particularly during surgical procedures, it becomes vulnerable to microbial invasion and subsequent infection [2]. Such wounds commonly exhibit cardinal signs of inflammation, including erythema, swelling, pain, increased local temperature, and occasionally systemic symptoms like fever [3]. Among various postoperative complications, surgical site infections (SSIs) remain one of the most significant, especially in low- and middle-income countries (LMICs), where infection prevention measures may be inadequate [4]. SSIs are globally acknowledged as one of the leading types of hospital-acquired infections, responsible for approximately 20% of all nosocomial infections [5]. According to the World Health Organization (WHO), the average SSI prevalence in LMICs is approximately 11.8%, which is notably higher than the 2–5% observed in high-income countries [6]. Cesarean section (CS), a frequently performed surgical procedure in obstetrics, carries a particularly high risk of SSI due to the anatomical and procedural nature of the operation [7]. A large-scale analysis of Demographic and Health Surveys (DHS) across 72 LMICs between 2010 and 2014 reported CS rates ranging from 0.6% in South Sudan to 58.9% in the Dominican Republic [8]. In Bangladesh, the CS rate escalated from just 3% in 2000 to over 33% by 2018, according to the Bangladesh Institute of Development Studies (BIDS), and this upward trend continues, particularly in urban tertiary healthcare centers. This increase has directly contributed to a corresponding rise in post-cesarean wound infections [9]. A variety of factors are associated with a heightened risk of postoperative wound infection. Patient-related factors include elevated body mass index (BMI >25), anemia, diabetes, immunosuppression, and malnutrition [10]. Procedural variables such as prolonged surgery, emergency interventions, premature rupture of membranes (PROM), contamination during operation, and surgeries performed by less experienced surgeons also play a significant role [11]. Moreover, gynecological procedures like abdominal hysterectomy and exploratory laparotomy are deemed high-risk due to their invasiveness and tissue manipulation. The presence of hematomas, foreign bodies, and trauma at the surgical site further increases susceptibility to infection [12]. The microbial etiology of SSIs is varied. Gram-positive bacteria such as Staphylococcus aureus and Streptococcus pyogenes are commonly isolated, while gram-negative organisms including Escherichia coli, Klebsiella spp., Pseudomonas aeruginosa, Enterobacter spp., and Proteus spp. are also prevalent [13]. Opportunistic fungal pathogens like Candida and Aspergillus species tend to infect immunocompromised patients [14]. The emergence of multidrug-resistant organisms has significantly complicated infection control efforts. SSIs generally develop between the fifth and eighth postoperative days, although early manifestations can appear by the third day, depending on pathogen virulence. Diagnosis is typically clinical, based on localized inflammation, purulent exudate, and wound pain [15]. The aim of this study was to determine the prevalence and identify the risk factors of surgical site wound infection, with a particular focus on microbial profiles among postoperative patients at DMCH.

MATERIAL AND METHODS

This prospective observational study was conducted at the Department of General Surgery, Prime Hospital, Dubai, UAE. The study spanned from January 2024 to December 2024, with complete follow-up of all participants. The objective was to evaluate the bacteriological profile of surgical wound infections and assess their clinical implications. A total of 150 patients who presented with clinical features suggestive of surgical wound infections were enrolled through purposive sampling.

Inclusion Criteria

- Patients aged 18 years and above.
- Patients presenting with clinical signs of surgical site infections (SSI) such as redness, pain, swelling, or discharge.
- Patients who had undergone surgeries like cesarean section, abdominal hysterectomy, or laparotomy.

Exclusion Criteria

- Patients already receiving antibiotic treatment for more than 72 hours before sample collection.
- Presence of fungal or viral wound infections.
- Patients with immunocompromised conditions (e.g., HIV, chemotherapy).
- Refusal to provide informed consent.

Ethical Considerations

Ethical approval was obtained from the Ethical Review Committee of [hospital name] before data collection. Participants were informed in their native language about the study's purpose, procedures, and their rights through a printed handout. Written consent was taken, ensuring confidentiality and voluntary participation without any impact on treatment or financial obligation.

Data Collection

Data were collected using a structured proforma, covering socio-demographic variables (age, occupation, BMI), surgical indications, comorbidities (diabetes, anemia), obstetric risk factors (PROM, preeclampsia), and hospital-related factors (length of hospital stay). Wound swab samples were aseptically collected from infected sites and sent to the microbiology laboratory for culture and sensitivity testing. Bacterial identification and antibiotic susceptibility testing were carried out following standard laboratory protocols, and multidrug resistance (MDR) was defined as resistance to at least one agent in three or more antimicrobial categories.

Statistical Analysis

Data were analyzed using SPSS software (version 26.0). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables were presented as frequencies and percentages. Comparison of variables between culture-positive and culture-negative groups, and between gram-positive and gram-negative infections, was done using Chi-square test or Fisher's exact test for categorical variables, and unpaired t-test for continuous variables. A p-value ≤ 0.05 was considered statistically significant.

RESULTS

Out of 150 patients with suspected surgical wound infections, 101 cases (67.3%) were culture-positive, while 49 cases (32.7%) were culture-negative, as shown in Figure 1. Table 1 described that Among culture-positive patients, 42.57% were aged 21–30 years, 36.63% were 31–40, and 20.79% were over 40, with a mean age of 33.2 ± 6.8 years. In contrast, 53.06% of culture-negative patients were over 40, with a higher mean age of 38.1 ± 7.4 years ($p<0.01$). Housewives were more common in the culture-negative group (73.47% vs 40.59%, $p<0.01$), while service holders predominated in the culture-positive group (49.50% vs 40.82%). Students (1.98%) and unemployed (23.76%) were found only among culture-positive cases. Mean BMI was similar between groups (24.8 ± 3.5 vs 25.5 ± 3.8; p=0.291). Table 2 reported bacterial isolates among culture-positive cases (n=101). Staphylococcus aureus was the most common (33.66%), followed by Escherichia coli (21.78%), Pseudomonas aeruginosa (19.80%), Acinetobacter spp. (14.85%), and Klebsiella pneumoniae (9.90%). Cesarean section was the surgical indication in 55.88% gram-positive and 56.72% gram-negative cases (p=0.932). Abdominal hysterectomy occurred in 23.53% vs 26.87% (p=0.717) and anemia in 88.24% vs 80.60% (p=0.352) (Table 3). Staphylococcus aureus (n=34) showed resistance to ceftriaxone in 64.70%, gentamicin in 41.20%, ciprofloxacin in 50.00%, and imipenem in 5.90% of cases. Escherichia coli (n=22) exhibited higher resistance: 81.80% to ceftriaxone, 68.20% to gentamicin, 63.60% to ciprofloxacin, and 13.60% to imipenem. Pseudomonas aeruginosa (n=20) showed resistance in 75.00% to ceftriaxone, 55.00% to gentamicin, 35.00% to ciprofloxacin, and 10.00% to imipenem. Acinetobacter spp. (n=15) had resistance rates of 80.00% to ceftriaxone, 73.30% to gentamicin, 66.70% to ciprofloxacin, and 6.70% to imipenem. Klebsiella pneumoniae (n=10) demonstrated the highest ceftriaxone resistance at 90.00%, along with 60.00% to gentamicin, 50.00% to ciprofloxacin, and 10.00% to imipenem (Table 4). PROM >12 hours occurred in 50.0% of gram-positive and 46.3% of gram-negative cases (p=0.745). Preeclampsia was noted in 22.7% of gram-positive and 20.9% of gram-negative infections (p=0.843). Meconium-stained liquor was present in 13.6% of gram-positive and 9.0% of gram-negative cases (p=0.523). Prolonged hospital stay (≥11 days) was seen in 23.5% of gram-positive and 20.9% of gram-negative infections (p=0.767) (Table 5). Table 6 presented that a high proportion of isolates exhibited MDR characteristics, with the highest rate found in Acinetobacter spp. (86.67%), followed by Klebsiella (80.00%), E. coli (77.27%), and Pseudomonas (70.00%). The overall MDR prevalence among gram-negative isolates was 77.61% (52 out of 67 isolates).

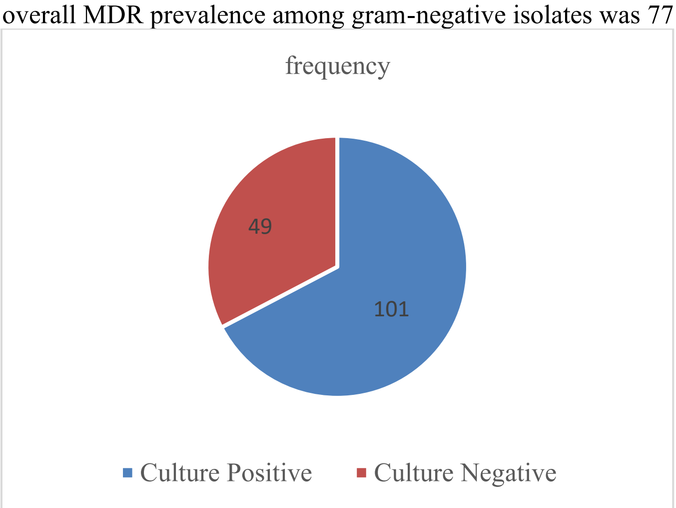

Fig 1: Distribution of Patients by Culture Results (n=150)

Table 1: Socio-Demographic Characteristics Associated with Bacteriological Culture Results (N = 150)

Variable	Culture Positive (n=101)		Culture Negative (n=49)		P-value
	frequency (n)	Percentage (%)	frequency (n)	Percentage (%)	
Age (Years)					
21-30	43	42.57	9	18.37	
31-40	37	36.63	14	28.57	
>40	21	20.79	26	53.06	
Mean ± SD	33.2 ± 6.8		38.1 ± 7.4		<0.01
Occupation					
Housewife	41	40.59	36	73.47	<0.01
Service	50	49.50	20	40.82	
Student	2	1.98	0	0.00	
Unemployed	24	23.76	0	0.00	
BMI					
Mean ± SD	24.8 ± 3.5		25.5 ± 3.8		0.291

Table 2: Bacterial Isolates Identified in Culture-Positive Surgical Wound Infections (n = 101).

Bacterial Isolate	Type	Frequency (n)	Percentage (%)
Staphylococcus aureus	Gram-positive	34	33.66
Escherichia coli	Gram-negative	22	21.78
Pseudomonas aeruginosa	Gram-negative	20	19.80
Acinetobacter spp.	Gram-negative	15	14.85
Klebsiella pneumoniae	Gram-negative	10	9.90

Table 3: Association of Surgical Indications and Comorbidities with Bacterial Type (n = 101)

Parameter	Gram-positive (n=34)		Gram-negative (n=67)		P-value
	frequency (n)	Percentage (%)	frequency (n)	Percentage (%)	
Cesarean section	19	55.88	38	56.72	0.932
Abdominal hysterectomy	8	23.53	18	26.87	0.717
Anemia	30	88.24	54	80.60	0.352
Diabetes mellitus	3	8.82	16	23.88	0.049

Table 4: Antibiotic Resistance Profile of Major Isolates (n = 101)

Organism	Ceftriaxone	Gentamicin	Ciprofloxacin	Imipenem
Staph. aureus (n=34)	64.70%	41.20%	50.00%	5.90%
E. coli (n=22)	81.80%	68.20%	63.60%	13.60%
Pseudomonas (n=20)	75.00%	55.00%	35.00%	10.00%
Acinetobacter (n=15)	80.00%	73.30%	66.70%	6.70%
Klebsiella (n=10)	90.00%	60.00%	50.00%	10.00%

Table 5: Obstetric and Hospital-Related Risk Factors According to Bacterial Type (n = 101)

Risk Factor	Gram-positive (%)	Gram-negative (%)	P value
PROM >12 hrs	11 (50.0%)	31 (46.3%)	0.745
Preeclampsia	5 (22.7%)	14 (20.9%)	0.843
Meconium-stained liquor	3 (13.6%)	6 (9.0%)	0.523
Hospital stay ≥11 days	8 (23.5%)	14 (20.9%)	0.767

Table 6: Multidrug Resistance (MDR) Among Gram-Negative Isolates (n=67)

Organism	MDR Isolates (n)	MDR Rate (%)
E. coli (n=22)	17	77.27
Pseudomonas (n=20)	14	70.00
Acinetobacter (n=15)	13	86.67
Klebsiella (n=10)	8	80.00
Total MDR	52	77.61

DISCUSSION

Surgical wound infections encompass a spectrum of bacterial contaminations ranging from superficial incisional infections to deep organ/space infections, each carrying distinct clinical implications [16]. In this study, we evaluated the bacteriological profile and antimicrobial resistance patterns in 150 patients with suspected surgical wound infections. Our culture positivity rate was 67.3%, which aligns with prior reports indicating culture positivity rates ranging from 70% in SWI cases [17]. The predominance of younger patients (21–40 years) in culture-positive cases, with a significantly lower mean age compared to culture-negative patients, suggests that younger, more active individuals might have higher exposure or susceptibility to wound contamination. Similar age distribution patterns were reported by Hasan et al., where younger adults formed the majority of SWI cases [18]. The most frequently isolated organism was *Staphylococcus aureus* (33.66%), consistent with the global predominance of *S. aureus* as a leading cause of surgical site infections (SSIs). A systematic review and meta-analysis reported S. aureus as the most common pathogen in SSIs, with a prevalence of 30.06% among identified organisms [19]. Gram-negative bacteria collectively accounted for a significant proportion (66.34%), with *Escherichia coli* (21.78%), *Pseudomonas aeruginosa* (19.80%), *Acinetobacter* spp. (14.85%), and *Klebsiella pneumoniae* (9.90%) being the major isolates. This finding is comparable to study conducted by Shah et al., which also reported a substantial presence of multidrug-resistant gram-negative pathogens in postoperative wound infections [20]. Our results revealed no significant difference between gram-positive and gram-negative isolates regarding surgical indications such as cesarean section and abdominal hysterectomy, nor in anemia prevalence, indicating that these factors alone may not predispose to specific bacterial types. However, diabetes mellitus was significantly associated with gram-negative infections, which corroborates earlier observations by Zhang et al. highlighting diabetes as a critical risk factor for infections caused by resistant gram-negative bacilli due to impaired host defenses [21]. The antibiotic resistance profiles observed in our isolates raise serious clinical concerns. Resistance to ceftriaxone was remarkably high across all major pathogens, with *Klebsiella pneumoniae* showing the highest resistance (90%). This aligns with the study of Lester et al. which indicated the increasing resistance among Enterobacteriaceae to third-generation cephalosporins [22]. Resistance rates to gentamicin and ciprofloxacin were also elevated, particularly in *Acinetobacter* and *E. coli*, reflecting widespread antibiotic misuse and selection pressure in healthcare settings [23]. The high prevalence of multidrug resistance (MDR) among gram-negative isolates (77.61%) is consistent with another recent study of Bangladesh reported MDR rates of 66.0% in clinical isolates from surgical wounds [24]. The predominance of MDR *Acinetobacter* spp. (86.67%) and *Klebsiella pneumoniae* (80%) underscores the urgent need for infection control strategies to limit nosocomial transmission of these formidable pathogens [25]. Obstetric risk factors such as prolonged rupture of membranes (PROM >12 hours), preeclampsia, and meconium-stained liquor showed no significant association with the type of infecting bacteria or hospital stay duration, consistent with findings by Sangwan et al., who also reported that while these factors contribute to infection risk, they do not significantly influence bacterial profiles or clinical outcomes [26]. Our study underscores the critical need for routine culture and sensitivity testing in managing SWIs, as empirical therapies based on outdated resistance patterns may fail, leading to increased morbidity and healthcare costs [27]. Implementation of robust antimicrobial stewardship programs, coupled with surveillance of resistance trends, is vital to combat the rising tide of MDR organisms in surgical settings.

Limitations of the study: This study was conducted at a single tertiary care center, limiting the generalizability of the findings to broader populations. The sample size, though adequate for preliminary conclusions, may not capture the full spectrum of bacterial diversity in surgical wound infections. Additionally, viral and fungal pathogens were excluded, potentially underestimating the true infectious burden. Molecular diagnostic methods were not employed, which may have limited the detection of fastidious or unculturable organisms and hindered resistance gene profiling.

CONCLUSION AND RECOMMENDATIONS

This study underscores the high burden of surgical wound infections in a tertiary care setting, with a culture-positivity rate of 67.3%, predominantly involving *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*. Alarmingly high rates of multidrug resistance, particularly among gram-negative organisms, highlight the growing threat of antimicrobial resistance in postoperative care. Significant associations with patient age, occupation, and type of surgery were observed, emphasizing the need for targeted infection prevention strategies. Timely microbiological diagnosis and susceptibility-guided antibiotic therapy are imperative to improve clinical outcomes and reduce hospital stays. These findings call for stricter antimicrobial stewardship and adherence to aseptic surgical protocols to curb SSI-related morbidity and the spread of resistant pathogens.

DECLARATIONS

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