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Research Article

High Burden of Surgical Site Infections After Emergency Trauma Laparotomy in a War-Affected Setting: A Prospective Cohort Study from Gaza

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Abstract

Background: After an emergency trauma laparotomy, surgical site infections (SSI) continue to be a leading cause of postoperative morbidity, especially in environments with limited resources and a history of violence. Due to extensive wound contamination, delayed presentation, and interruption of routine perioperative and infection prevention procedures, armed conflict increases the risk of infection.

Objectives: The purpose of this study is to ascertain the prevalence, trends, and contributing variables of surgical site infections after emergency trauma laparotomy in a healthcare system devastated by war, as well as to pinpoint useful areas for infection control in austere emergency surgical settings.

Methods: Three major Gaza Strip referral hospitals participated in a prospective cohort study from October to December 2023. We considered successive violent injury victims who had emergency laparotomies. Prospective clinical, surgical, injury-related, and demographic data were collected. Within 14 days after surgery, surgical site infections were evaluated according to the Centers for Disease Control and Prevention's criteria. The Chi-square test was used to assess relationships between possible risk variables and the incidence of SSI.

Findings: There were 126 patients in all. The incidence of SSI was 34.7% overall. The most prevalent kind of incisional infection was superficial, which was followed by deep and organ/space infections. The development of SSI was substantially correlated with wound categorization, with contaminated wounds showing greater infection rates than dirty wounds ($p = 0.013$). There were no statistically significant correlations found between SSI and the existence of other injuries, smoking status, length of operation, or patient comorbidities. Culture-positive infections were primarily caused by gram-negative organisms, and SSI was linked to longer hospital stays and readmissions due to infection.

Conclusion: In conclusion, wound contamination and system-level limitations are the main causes of the significant early SSI burden linked to emergency trauma laparotomy in conflict situations. In health systems damaged by conflict, specific, workable infection control measures are necessary to lower postoperative morbidity and maintain emergency surgical capacity.

Keywords: *Surgical Site Infection; Emergency Surgery; Trauma Laparotomy; War-Related Injury; Resource-Limited Settings*

Abbreviations

SSI: Surgical Site Infections; CDC: Centers for Disease Control and Prevention's

Introduction

Emergency trauma surgery and SSI burden

Surgical site infection (SSI) is still one of the most common and serious complications after surgery worldwide. It leads to more illness, longer hospital stays, greater use of antibiotics, and higher costs. International guidelines highlight that SSI risk depends heavily on peri-operative practices, such as giving antibiotics on time, proper antisepsis, controlling temperature and blood sugar, and good wound care. The risk is especially high in emergency surgeries, where there is less time to prepare patients [1-4]. SSIs also put a major strain on health systems. For example, in a large U.S. study, SSI was the top reason for unplanned readmission after several major surgeries [5]. The problem is even worse in resource-limited settings. In developing countries, SSI is often the most common hospital-acquired infection, mainly because of limited infrastructure, staff, sterile supplies, and surveillance [6].

Surgical care in conflict and resource-limited settings

A higher infection risk in emergency surgery and more stringent prevention measures are reported in conflict areas. As high-energy blasts and penetrating injuries often lead to heavy contamination, dead tissue, delays in transport, and disrupted surgical routines [2,3]. Recent studies of trauma care in the Gaza conflict show the intense pressure hospitals face in urban warfare, highlighting the need to adapt trauma protocols when resources are limited [7]. Shortages, crowding, frequent patient transfers, and limited laboratory facilities negatively affect infection prevention [1-4]. Because of this, preventing surgical site infections in conflict areas should focus on practical, effective measures that remain effective even when sterility, staffing, and monitoring are disrupted.

Knowledge gap and study rationale

While SSI risk factors are well-known in stable health systems, there is limited evidence from trauma laparotomy cases in conflict zones, especially when it comes to prospective data on incidence and local risk factors. Studies show that contaminated and dirty wounds are common in trauma laparotomies and carry a high risk of SSI, but closure methods and preventive practices differ widely [2,8]. Risk models highlight that injury patterns and the surgical setting are important for organ/space SSI in trauma laparotomy [8]. Still, it is unclear how these factors play out in war-affected, resource-limited hospitals, where following standard protocols can be challenging. More local evidence is needed to guide practical prevention strategies.

Study Aim and Objectives

This study measured how often surgical site infections (SSIs) occur after emergency trauma laparotomy in a conflict-affected area and looked at important factors related to patients, injuries, surgery, and care before and after the operation. The study aims to guide practical, context-specific strategies for infection prevention and postoperative care in challenging emergency surgical settings.

Materials and Methods

This prospective cohort research was carried out in the Gaza Strip between October 1, 2023, and December 1, 2023, while there was an ongoing armed war. Patients with war-related traumatic injuries who had emergency exploratory laparotomies at three major referral hospitals-Public Aid Hospital in North Gaza, Nasser Medical Complex in South Gaza, and Al-Aqsa Hospital in Middle Gaza-were included in the study. During the research period, mass casualty situations and significant resource restrictions were prevalent in all participating hospitals.

Inclusion was open to all consecutive patients, regardless of age or gender, who needed an emergency laparotomy as a result of blunt or penetrating injuries received during the battle. Individuals with known immunodeficiency, immunosuppressive treatment, pre-existing infections unrelated to the surgical site, or re-operation at the same surgical site for non-infectious causes were not included in the study. In accordance with observational studies in emergency and austere settings, a convenience sample strategy was used due to security constraints, hospital congestion, and sporadic service interruptions [9]. Out of the 128 patients that were recruited, 126 were included in the final analysis since two patients passed away during follow-up.

A consistent computerized data collecting tool was used to gather data prospectively through patient interviews, medical record reviews, and consultations with treating surgeons. Affected organs, comorbidities, displacement status, demographics, injury type, and related injuries were among the variables. Preoperative preparatory procedures, blood transfusions, wound classification, length of operation, intraoperative antibiotic prophylaxis, surgical problems, drain installation, and completeness of documentation were all included in the peri-operative data. Antibiotic medication, fever, test abnormalities, wound features, and clinical symptoms of infection were among the postoperative data.

The Centers for Disease Control and Prevention's (CDC) surgical wound categorization system was used to categorize surgical wounds [10]. According to CDC definitions, surgical site infections (SSIs) were classified as organ/space, deep incisional, and superficial incisional [11]. SSIs were evaluated within 14 days postoperatively, a strategy previously documented in trauma and austere surgical settings, due to the limitations of extended hospitalization and patient displacement during the conflict [12]. Purulent drainage, localized pain, swelling, erythema, abscess development, or clinician diagnosis, supported by microbiological confirmation when cultures were available, were among the clinical evaluations used by treating doctors to make the diagnosis of SSI.

In order to evaluate postoperative outcomes, such as the incidence of SSI, readmission, need for treatment at another facility, length of hospital stay, and wound management techniques, patients were monitored both during their hospital stay and following their release through outpatient clinic visits or direct contact. Isolated organisms and antibiotic changes were recorded when wound cultures were carried out.

SPSS v 31.0.1.0 was used to examine the data. Variables were summarized using descriptive statistics as means with standard deviations or medians with interquartile ranges for continuous data, and as frequencies and percentages for categorical data. The Chi-square test was used to evaluate associations between specific factors and the occurrence of SSI; a two-sided p-value of less than 0.05 was deemed statistically significant [13].

The study received ethical approval from the Islamic University of Gaza's Faculty of Medicine and the Gaza Strip's Ministry of Health. Every participant or their legal guardian provided written informed consent. In compliance with international ethical guidelines for research involving human participants in conflict situations, all data were anonymised, safely kept, and handled only by the study team [14].

Results

The final study comprised 126 individuals receiving emergency trauma laparotomy. With 66.1% of the cohort aged 18 - 65 and 32.3% under 18, the cohort was primarily youthful and male (68.5%). At the time of injury, almost half of the patients (54.0%) had internal displacement. Patients were treated at three of Gaza's main referral hospitals, with admissions representing a wide geographic range. Table 1 provides a summary of the surgical, injury-related, clinical, and demographic features.

98.4% of the injuries were penetrating, which is consistent with trauma mechanisms connected to combat. Crucially, there were no documented clean or clean-contaminated wounds. According to intraoperative wound categorization, 32.3% of wounds were filthy, and

67.7% of wounds were polluted. The majority of treatments (64.5%) were finished in three hours, and the majority of patients (80.6%) only had one surgical intervention. All patients received intraoperative antibiotic prophylaxis. Table 1 provides specifics on wound and operational parameters.

Domain	Variable	Category	n (%)
Demographics	Sex	Male	85 (68.5%)
		Female	39 (31.5%)
	Age	<18 years	40 (32.3%)
		18-65 years	82 (66.1%)
		>65 years	2 (1.6%)
	Displacement	Displaced	67 (54.0%)
		Non-displaced	57 (46.0%)
Clinical	BMI	Underweight	26 (21.0%)
		Normal	66 (53.2%)
		Overweight	28 (22.6%)
		Obese	4 (3.2%)
	Comorbidities	Any comorbidity	14 (11.1%)
		None	112 (88.9%)
Injury	Mechanism	Penetrating	122 (98.4%)
		Blunt	2 (1.6%)
	Affected organs	Small bowel	65 (52.4%)
		Large bowel	52 (42.0%)
		Liver	33 (26.6%)
		Spleen	24 (19.4%)
Operative	Wound class	Contaminated	84 (67.7%)
		Dirty	40 (32.3%)
	Duration	<3 hours	80 (64.5%)
		≥3 hours	44 (35.5%)
	Number of operations	One	100 (80.6%)
		≥Two	24 19.4%)

Table 1: *Demographic, clinical, injury, and operative characteristics of the study cohort.*

Incidence and spectrum of surgical site infection

An overall SSI rate of 34.7% was obtained from 43 patients who had surgical site infections over the 14-day postoperative monitoring period. The most common manifestation among impacted individuals was superficial incisional SSI (29.8%), which was followed by organ/space infection (12.9%) and deep incisional infection (10.5%). Localized erythema, edema, purulent fluid, and fever were some of the clinical observations. Table 2 shows the spread of SSI types and results linked to surgical infections.

Postoperative course and clinical outcomes

64.5% of patients experienced postoperative fever, with a mean temperature of more than 39°C. There was no statistically significant correlation seen between the development of SSI and the occurrence of concurrent injuries, although around half of the sample experienced additional severe injuries beyond the laparotomy region. 46.0% of patients remained in the hospital for more than 14 days, indicating that hospital stays were often protracted. Infection-related readmissions occurred in 8.0% of cases, while capacity concerns necessitated treatment at other facilities in 4.8% of cases. Postoperative results and healthcare usage indicators are collected in table 2.

Microbiological findings and antibiotic escalation

Microbiological cultures were taken from 15.3% of patients who were thought to have an illness. A large proportion of positive cultures (42.1%) were composed of Gram-negative bacteria. *Escherichia coli* was the most common strain (31.5%), followed by *Pseudomonas* and *Klebsiella* species. A lot of the time, culture results led to more antibiotics, and most of the time, broad-spectrum treatments were needed. Table 2 shows these findings.

Statistical analysis and factors associated with SSI

The Chi-square (χ^2) test was used to examine how category factors were associated with the number of SSIs. There was a statistically significant link between the growth of SSI and the type of wound. Infected wounds were more likely to be infected than dirty wounds (χ^2 p = 0.013). According to this research, the main factor influencing postoperative infection in this group is wound contamination.

Conversely, no statistically significant correlations were found between the frequency of SSI and smoking status (χ^2 p = 0.14), comorbidities (χ^2 p = 0.46), length of surgery (χ^2 p = 0.14), length of stay prior to surgery (χ^2 p = 0.61), or other injuries (χ^2 p = 0.95). These findings suggest that environmental and intraoperative variables were more significant than conventional patient-related risk factors in this group affected by war (Table 2).

Variable	Category	SSI (n)	No SSI (n)	Total n (%)	P-value (χ^2)
Smoking status	Smoker	9	9	18 (14.5%)	0.14
	Non-smoker	34	72	106 (85.5%)	
Comorbidities	Present	3	9	12 (9.7%)	0.46
	Absent	40	72	112 (90.3%)	
Operation duration	<3 hours	24	56	80 (64.5%)	0.14
	≥3 hours	19	25	44 (35.5%)	
Wound classification	Contaminated	23	61	84 (67.7%)	0.013*
	Dirty	20	20	40 (32.3%)	
Additional injuries	Present	18	29	47 (37.3%)	0.95
	Absent	25	54	79 (62.7%)	
Postoperative fever	Yes	32	48	80 (64.5%)	0.18
	No	11	35	46 (35.5%)	
Readmission due to SSI	Yes	10	0	10 (8.0%)	—
	No	33	83	116 (92.0%)	
Culture obtained	Yes	19	0	19 (15.3%)	—
	No	24	83	107 (84.7%)	
Dominant organism	Gram-negative	8	—	8 (42.1%)	—
	E. coli	6	—	6 (31.5%)	—
Hospital stay	<7 days	6	23	29 (23.4%)	0.02
	7-14 days	13	25	38 (30.6%)	
	>14 days	24	33	57 (46.0%)	

Table 2: *Postoperative outcomes, surgical site infections, microbiology, and statistical associations.*

Assessment and follow-up features throughout the perioperative period

A comprehensive assessment throughout the perioperative phase indicated considerable delays in obtaining definitive surgical intervention. A majority of patients (60.5%) came following protracted prehospital delays, whereas just 39.5% presented within 6 hours of injury. Preoperative antibiotic medication was administered to all patients, and almost half of them needed a blood transfusion during the operation (46.8%). The results of the operations showed significant contamination: 66 percent of the wounds were deemed infected, and 33 percent were deemed filthy. The majority of surgeries were completed within 3 hours, and about 20% of patients required further surgical interventions. Nearly two-thirds of patients experienced fever after surgery, and over a third got an infection at the incision site. There was a high risk of readmission due to SSI, and the majority of patients stayed in the hospital for more than 14 days, according to follow-up data. Table 3 summarizes the characteristics of perioperative assessment and follow-up.

Preoperative assessment	Time to presentation	≤6 hours	49 (39.5%)
		>6 hours	75 (60.5%)
	Preoperative antibiotics	Received	126 (100%)
	Blood transfusion	Yes	58 (46.8%)
		No	66 (53.2%)
Operative assessment	Wound classification	Contaminated	84 (67.7%)
		Dirty	40 (32.3%)
	Duration of surgery	<3 hours	80 (64.5%)
		≥3 hours	44 (35.5%)
	Number of operations	One	100 (80.6%)
		≥Two	24 (19.4%)
Postoperative assessment	Postoperative fever	Yes	80 (64.5%)
		No	44 (35.5%)
	Any surgical site infection	Yes	43 (34.7%)
		No	81 (65.3%)
	Type of SSI	Superficial	37 (29.8%)
		Deep	13 (10.5%)
		Organ/space	16 (12.9%)
Postoperative follow-up	Length of hospital stay	>14 days	57 (46.0%)
		7-14 days	38 (30.6%)
		<7 days	29 (23.4%)
	Readmission due to SSI	Yes	10 (8.0%)
		No	116 (92.0%)
	Culture obtained	Yes	19 (15.3%)
		No	107 (84.7%)

Table 3: *Perioperative assessment and follow-up.*

Discussion

Principal findings

In a health system that has been affected by conflict, this prospective cohort shows a high early SSI burden (34.7% within 14 days) after emergency trauma laparotomy. A large number of organ/space SSIs were part of the infection spectrum, which is typical of wartime laparotomy care because of the high levels of contamination and physiological stress.

Contaminated wounds have much higher infection rates than dirty wounds (χ^2 test, $p = 0.013$). However, traditional patient-level predictors (smoking, comorbidity burden) and some operative variables (duration categories) did not show any signs of being linked. The postoperative course was marked by long hospital stays, high rates of readmission due to infections, and a microbiology dominated by gram-negative organisms. This shows how complicated SSI is from both a clinical and system-wide point of view (Table 1 and 2).

Comparison with existing literature

Organ/space infections continue to be clinically significant, and our observed SSI incidence is in line with-and in some analyses higher than-reported rates following emergency trauma laparotomy, when superficial SSI rates alone have been described as large [15]. Contamination burden, intestinal damage, and the emergency character of surgery-which restricts preoperative optimization and increases exposure to sterile technique breaches under time pressure-are the greatest and most consistent indicators of SSI across trauma groups [15,16]. Furthermore, there are differences in the ways that trauma laparotomy wounds are managed.

The importance of bacterial inoculum, tissue devitalization, and contamination severity is reflected in studies assessing contaminated/dirty trauma laparotomy wounds, which show persisting SSI risk across closure techniques [17]. The assumption that patient comorbidities may contribute less to risk variation in high-contamination conditions than the surgical field and perioperative environment is supported by our observation that wound class was the only statistically significant predictor.

In terms of microbiology, the predominance of gram-negative organisms in infected wounds is also consistent with emergency general surgery patterns and abdominal trauma, where enteric organisms and polymicrobial infections frequently cause superficial and organ/space SSIs-especially when bowel injury, delayed definitive management, and repeated abdominal interventions take place [15,17]. Concerns expressed in guideline-based preventive work, which highlights that preventative bundles (timely prophylaxis, antisepsis, wound care, and monitoring) minimize avoidable SSI and antibiotic misuse, are echoed by the reported requirement for antibiotic escalation in culture-positive patients [1-4].

Impact of war and health system constraints

War zones' surgical units have several challenges, including delayed patient presentation, interrupted supply chains, congestion, inadequate cleaning capacity, and a lack of access to sophisticated wound care and diagnostic microbiology. A number of studies, both qualitative and quantitative, have shown that SSIs rank high among healthcare-associated infections in hospitals hit by violence. SSIs are one of the most common infections linked to healthcare, according to both qualitative and systems-level studies of how to avoid and control infections in hospitals that have been affected by war. This is because of problems with water and sanitation, staffing levels, infrastructure damage, and a lack of antiseptics and personal protective equipment [18]. During times of armed conflict, humanitarian surgery frameworks stress that it can be hard to keep up with basic standards like sterile processing, antibiotics during surgery, consistent dressing supplies, and reliable follow-up. This means that high-yield interventions and simplified protocols need to be prioritized [19].

In this study, longer stays, readmissions, and going to different facilities for care show how SSIs add to system stress: each infection uses up beds, dressings, medicines, and staff time, all of which are already being used up by the large number of deaths. The observed culture patterns and increasing pressures also make people worry that conflict conditions may speed up the wrong use of antibiotics and the development of drug resistance, which will make future care even more difficult.

Clinical and emergency care implications

These results back up a clear operational message for emergency surgical services in conflict zones: keep things clean and make sure that SSI-prevention actions are always taken. This can be done by always giving the right prophylactic antibiotics at the right time and in the right amount, carefully cleaning up wounds and controlling their sources, and following the same steps for wound care after surgery. If resources are available, targeted culture acquisition in worsening cases can support stewardship and prevent empiric escalation from lasting too long. Our data show that improving the reliability of the environment and operations (such as ensuring sterile supplies, adequate dressing availability, and follow-up access) may lead to larger decreases in SSIs than simply looking at comorbidity profiles to identify who is at risk.

Study Limitations

There are a few restrictions to consider. First, the 14-day follow-up period probably underreported SSIs that manifest later (especially organ/space infections), although this is indicative of practical limitations in a community that has been relocated and the healthcare system is disturbed. Second, because only a small portion of likely diseases were culture-sampled, microbiological generalizability was constrained. Lastly, the results may not be entirely applicable to trauma systems outside of war since they represent the operational reality of three large hospitals in Gaza during the crisis.

Conclusion

This prospective cohort research shows that over one-third of emergency trauma laparotomy patients in a conflict-affected health system acquire surgical site infection (SSI) prematurely. Emergency surgery, significant wound contamination, and severe system restrictions appear to drive postoperative infection more than conventional patient-related risk factors. Limited resources and disturbed healthcare services lead to vulnerable trauma patients in war zones. SSIs contribute to morbidity and health system pressure in such settings, not only postoperative problems. Thus, war zones require context-specific SSI methods that promote practicality, quick deployment, and maximum effect within restricted emergency surgical resources.

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Conflict of Interest

The authors declare no conflicts of interest related to this study.

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