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Original Article

Clinico-microbiological evaluation of post-cesarean surgical site infections

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ABSTRACT

Objectives: With increasing rates of cesarean section (CS), the incidence of post-operative complications is bound to increase, which includes surgical site infections (SSIs), being one of the common and distressing complication. This study was aimed to evaluate the various determinants of post-CS SSI, their clinical spectrum, prevalent microbiology, and their susceptibility and resistance patterns.

Materials and Methods: This was a prospective longitudinal hospital-based study undertaken in Government Medical College and Hospital (GMCH), Chandigarh. Six hundred and eighty-eight patients were included from April, 2021, to September, 2022, and were followed up till 42nd day post-procedure.

Results: The incidence of SSI in the study was 3.49%. The risk factors identified were gestational diabetes mellitus (GDM), thrombocytopenia, chorioamnionitis, prolonged labor, multiple per vaginum examinations, prolonged surgery, post-partum hemorrhage, and blood and blood product transfusions. Most patients presented on or after day 8 of surgery with discharge from the wound site being the most common presentation. *Staphylococcus aureus* emerged as the most prevalent organism and out of five patients having *S. aureus*, three had methicillin-resistant *S. aureus*. Linezolid was found to be the most susceptible antibiotic, whereas ciprofloxacin was mostly resistant among the prevalent isolates.

Conclusion: Some of these determinants are modifiable such as GDM and thrombocytopenia and if detected and managed early may help in reducing the risk of developing SSI. Linezolid must be used empirically for treatment of SSI until the reporting of culture and sensitivity is done because routine antibiotics used for antibiotic prophylaxis in CS were found to be highly resistant. Periodic analysis of clinical spectrum and culture and sensitivity patterns is imperative for the early diagnosis and appropriate empirical management of SSI.

Keywords: Cesarean section, Surgical site infections, Risk factors, *Staphylococcus aureus*, Linezolid

INTRODUCTION

Cesarean section (CS) is a widely performed procedure in modern obstetrics aimed at enhancing maternal and neonatal outcomes when vaginal delivery is deemed risky or unfeasible. Despite its intended purpose, the global surge in CS rates, particularly in India, has raised concerns.[1] The World Health Organization suggests an optimal CS rate of 10–15%, yet India's rates escalated from 8.5% in 2005–2006 to 21.5% in 2019–2021, as reported by the National Health Systems Resource Center (NHSN).[1-3] The escalating CS rates bring about an inevitable rise in post-operative complications, notably surgical site infections (SSIs), contributing to maternal morbidity, mortality, psychological distress, extended hospital stays, increased treatment costs, and strain on health-care facilities.[4]

Various risk factors contribute to the occurrence of SSI, encompassing maternal pre-existing comorbidities, obstetrical factors (parity, preterm rupture of membranes, prolonged labor, meconium-stained liquor, chorioamnionitis, gestational diabetes mellitus [GDM], anemia, previous CS, excessive vaginal manipulation), socioeconomic status, and illiteracy. Factors such as the type of ward, emergency or elective procedures, type of anesthesia, abdominal incision type, and overall procedure duration also impact SSI rates. Low socioeconomic status and illiteracy heighten infection risks due to overcrowded living conditions and lack of awareness regarding surgical site care.

SSI, occurring within 30 days post-CS, is categorized by the Centers for Disease Control and Prevention (CDC) into superficial incisional SSI, deep incisional SSI, and organ/space infections. It manifest with symptoms such as purulent discharge, pain, erythema, induration, local temperature elevation, and fever.[5] Common pathogens

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associated with SSI include Staphylococci, Streptococci, Enterococci, Lactobacilli, Diphtheroid, *Escherichia coli*, Anaerobic Streptococci, *Bacteroides*, and *Fusobacterium* species depending on the factors responsible for infection and prevalence of microbes in a particular health-care facility or area.[6,7]

The consequences of SSI extend beyond immediate health implications, encompassing indirect costs such as loss of productivity, patient dissatisfaction, litigation, and diminished quality of life. Preventing SSI involves addressing predisposing risk factors and understanding the microbial spectrum and antibiotic sensitivity in a healthcare setting, thereby improving prognosis and reducing morbidity associated with CS.

MATERIALS AND METHODS

This study was a prospective longitudinal hospital-based study that aimed to calculate the incidence of SSIs after CSs and evaluate the various determinants of post-CS SSI, their clinical spectrum, prevalent microbiology, and their susceptibility and resistance patterns. The study was conducted in the Department of Obstetrics and Gynecology in collaboration with the Department of Microbiology at Government Medical College and Hospital (GMCH) sector-32, Chandigarh. Optimum sample size was calculated on the basis of 7% incidence of SSI after CSs.[6] Assuming 95% confidence level and 10% precision, the sample size came out to be 385. We planned to take at least 385 subjects who complete the follow-up at 6 weeks. The study lasted 18 months from April 2021 to September 2022. Seven hundred patients were enrolled, out of which 688 patients completed the follow-up. The condition of their surgical scar/wound was assessed. The inclusion criteria for the study were patients undergoing CS at GMCH, who gave consent for the study and follow-up and SSI occurring within 42 days of CS.

The exclusion criteria were patients undergoing CS outside GMCH, patients having uterine rupture, patients undergoing peripartum hysterectomy, immunocompromised patients, and patients who refused to give consent for the study and follow-up.

Factors such as age, parity, background, socioeconomic status, education level, preterm rupture of membranes, prolonged labor, GDM, overt diabetes mellitus, anemia, previous CS, multiple vaginal examinations, emergency or elective case, post-partum hemorrhage, type of anesthesia, type of abdominal incision, meconium staining of liquor, chorioamnionitis, duration of surgery, malnutrition, obesity, hypertension, and any chronic disorders were noted. The surgical wound was examined at the time of first dressing, at 8–12 days post-cesarean, as and when required, and on day 42 of CS. Diagnosis of SSI was made according to the CDC standards, which involve infection that occurs within 30 days (extended to 42 days for this study).[5] After taking the wound swabs, where indicated, patients were treated according to ideal standard of care, which involved antibiotics, dressings, debridement, resuturing, readmission, etc. Swabs were sent for culture and sensitivity to microbiology laboratory. Isolation and susceptibility testing of culture isolates was done in our clinical microbiology laboratory using standard methods.[8] Antimicrobial susceptibility of culture isolates was done using Kirby-Bauer's disk diffusion method according to recent Clinical and Laboratory Standards Institute (CLSI) guidelines.[9]

RESULTS

A total of 700 post-CS patients were enrolled out of which ten patients lost to follow-up and two patients expired. Hence, 688 patients were studied and follow-up was done till 42 days after CS. Twenty-four patients developed SSI making the incidence to be 3.49%. Various determinants of post-CS SSIs were studied. GDM and thrombocytopenia were among the maternal factors which had significant association with SSI. Maternal obstetric factors such as chorioamnionitis, prolonged labor, and multiple per vaginum examinations also significantly increased the risk of SSI. Prolonged surgery, post-partum hemorrhage, and blood product transfusions also were major risk factors for developing SSI. The following table depicts various determinants studied and their association with the risk of developing post-cesarean SSI [Table 1]. Mean time of detection of SSI was 11.75 ± 3.232 day. Out of 24 patients, 18 had purulent discharge whereas four had serous discharge. Fifteen patients had pain and tenderness, eight had induration and swelling, five were febrile, and two developed erythema. Only six patients developed dehiscence of wound, as evident [Table 2]. Twenty-two out of 24 were superficial SSI, whereas two patients had deep SSI.

Culture report

All wound swabs were subjected to antimicrobial susceptibility testing using Kirby-Bauer's disk diffusion method according to recent CLSI guidelines wherein antibiotic panel checked was according to the kind of organism being cultured, so all organisms were not checked for similar antibiotics.[9] Eighteen organisms were isolated from wound swab. Six swabs were sterile. Out of 18, five were *Staphylococcus aureus*, four other *Staphylococcus* species, four *E. coli*, two *Klebsiella pneumoniae*, one *Acinetobacter*, one *Citrobacter koseri,* and one *Enterococcus faecium*. Moreover, out of five patients having *S. aureus*, three had methicillin resistant *S. aureus* [Table 3].

Antimicrobial susceptibility and resistance pattern

All wound swabs were subjected to antimicrobial susceptibility testing using Kirby-Bauer's disk diffusion

Table 1: Various risk factors associated with SSI.

Variables	Categories	Post-CS SSI		*P*-value	Odds ratio
		Yes	No		
Age group (years)	≤20	3	47	>0.05	
	21–25	6	230		
	26–30	7	236		
	31–35	6	116		
	>35	2	35		
Socioeconomic status	Lower	2	47	>0.05	
	Upper lower	2	112		
	Lower middle	9	284		
	Upper middle	9	179		
	Upper	2	42		
Background	Rural	13	341	>0.05	1.119, (95% CI, 0.494–2.535)
	Urban	11	323		
Education	Illiterate	4	102	>0.05	
	Undergraduate	11	405		
	Graduate and above	9	157		
BMI	Underweight	1	4	>0.05	
	Normal weight	2	175		
	Overweight	6	193		
	Obese I	13	246		
	Obese II	2	46		
Obese	Yes	15	292	>0.05	2.1233, (95% CI 0.9162–4.9208)
	No	9	372		
Anemia	Yes	6	249	>0.05	0.5556, (95% CI 0.2176–1.4183)
	No	18	415		
GDM	Yes	5	44	<0.05	3.708, (95% CI 1.3218–10.4024)
	No	19	620		
Hypertensive disorders of pregnancy	Gestational hypertension	0	56	>0.05	
	Preeclampsia	8	150		
	HELLP syndrome	1	4		
	Eclampsia	0	13		
Thrombocytopenia (platelet count <1 lakh per μL)	Yes	7	70	<0.05	3.494, (95% CI 1.4003–8.7188)
	No	17	594		
Parity	Multiparous	11	346	>0.05	0.7778, (955 C1 0.3435–1.7609)
	Primiparous	13	318		
Previous history of CS	Yes	5	227	>0.05	0.5066, (95% CI 0.1867–1.3745)
	No	19	437		
Past history of tuberculosis	Yes	0	4	>0.05	
	No	24	660		
Overt diabetes	Yes	0	22	>0.05	
	No	24	642		
Chronic hypertension	Yes	1	26	>0.05	1.0669, (95% CI 0.1387–8.2066)
	No	23	638		
Thyroid disorders	Yes	3	49	>0.05	1.7930, (95% CI 0.5167–6.2222)
	No	21	615		
Bronchial asthma	Yes	1	3	>0.05	9.5797, (95% CI 0.9594–95.6531)
	No	23	661		
POG	<32 weeks	3	41	>0.05	
	32–36+6 weeks	8	257		
	More than 37 weeks	13	366		
CS done in labor	Yes	14	355	>0.05	1.2186, (95% CI 0.5336–2.7827)
	No	10	309		
Prolonged labor	Yes	7	71	<0.05	3.4391, (95% CI 1.3788–8.5779)
	No	7	593		

(*Contd*...)

Table 1: (*Continued*).

Variables	Categories	Post-CS SSI		*P*-value	Odds ratio
		Yes	No		
Multiple per vaginum examinations	No	6	66	<0.05	3.02, (95% CI 1.1584–7.8744)
	Yes	18	598		
Duration of rupture of membranes	Not ruptured	9	361	>0.05	
	<24 h	13	258		
	>24 h	2	45		
PPROM	Yes	3	114	>0.05	0.6892, (95 % CI 0.2022–2.3496)
	No	21	550		
MSL	Yes	9	183	>0.05	1.5770, (95% CI 0.6783–3.6668)
	No	15	481		
Chorioamnionitis	Yes	2	7	<0.05	8.5325, (95% CI 1.6753–43.4574)
	No	22	657		
Place of hospital stay	General ward	19	627	>0.05	0.2242, (95% CI 0.0793–0.6341)
	Private ward	5	37		
Emergency versus elective CS	Elective	5	58	>0.05	0.3637, 95% CI 0.1310–1.0099
	Emergency	19	606		
Type of abdominal incision	Transverse	21	642	>0.05	4.168, (95% CI 1.1565–15.0270)
	Vertical	3	22		
Prolonged surgery	>2 h	3	19	<0.05	4.8647, (95% CI 1.3352–17.7236)
	<2 h	21	647		
Type of anesthesia	General	6	105	>0.05	1.7746, (95% CI 0.6883–4.5757)
	Spinal	18	559		
Post-partum hemorrhage	Yes	6	62	<0.05	3.237, (95% CI 1.2390–8.4548)
	No	18	602		
Blood and blood products transfusion	Yes	9	137	<0.05	2.308, (95% CI 0.9889–5.3866)
	No	15	527		
Time of start of antibiotics	30–60 min before	22	633	>0.05	1.856, (95% CI 0.4176–8.2513)
	>60 min before	2	31		
Ampicillin versus Ceftriaxone	Ampicillin	18	394	>0.05	2.056, (95% CI 0.806–5.246)
	Ceftriaxone	6	270		

SSI: Surgical site infection, CS: Cesarean section, BMI: Body mass index, GDM: Gestational diabetes mellitus, CI: Confidence interval, POG: Period of gestation, PPROM: Preterm prelabor rupture of membranes, MSL: Meconium stained liquor, HELLP: Hemolysis, elevated liver enzymes, low platelet count

Table 2: Signs and symptoms of SSI.

Signs and symptoms	Number of patients	Percentage
Fever	5	20.83
Wound dehiscence	6	25.00
Tenderness and pain	15	62.50
Purulent discharge	18	75.00
Serous discharge	4	16.67
Induration and swelling	8	33.33
Erythema	2	8.33

SSI: Surgical site infection

Table 3: Cultured isolates from wound swabs.

Culture report	Number of isolates	Percentage
Staphylococcus aureus	5	20.83
Acinetobacter	1	4.17
Citrobacter koseri	1	4.17
Enterococcus faecium	1	4.17
Escherichia coli	4	16.67
Klebsiella pneumoniae	2	8.33
Other *Staphylococcus* species	4	16.67
Sterile	6	25.00
Total	24	100

method according to recent CLSI guidelines wherein antibiotic panel checked was according to the kind of organism being cultured, so all organisms were not checked for similar antibiotics. Antimicrobial susceptibility and resistance among various isolates is shown in following [Table 4].

DISCUSSION

The incidence of SSI in the study was 3.49% in 688 post-CS patients and it was found to be lower than some past studies due to the strict antibiotic policy and asepsis in the operation theatre of the tertiary care center where the study

Table 4: Antimicrobial sensitivity of the cultures isolates.

	Penicillin	Ampicillin	Erythromycin	Clindamycin	Doxycycline	Ciprofloxacin	Gentamycin	Amikacin	Tobramycin	Ceftazidime	Cefepime	Sulbactam-Ampicillin	Tazobactam-Piperacillin	Imipenem	Cefoxitin	Tetracycline	Cefotaxime	Vancomycin	Linezolid	Cotrimoxazole
Staphylococcus aureus																				
S	0		2	3	3	0	0								2				5	0
R	5		3	2	2	1	1								3				0	1
Staphylococcus other																				
S	3		1	2	4	0	0								4				4	1
R	1		3	2	0	2	2								0				0	1
Escherichia coli																				
S						1		3		1	0		3	1			0			1
R						3		1		3	4		1	3			4			3
Klebsiella pneumonia																				
S						0		2		0	0		1	2			0			0
R						2		0		2	2		1	0			2			1
Acinetobacter																				
S						0	0	0	0	0	0	0	0	0		1	0			0
R						1	0	1	1	1	0	1	1	1		0	0			0
Enterococcus faecium																				
S	0	0	0		0	0	0									0		1	1	
R	1	1	1		1	1	1									1		0	0	
Citrobacter koseri																				
S						1		1		1	1		1	1			1			0
R						0		0		0	0		0	0			0			0

S: Sensitive, R: Resistant

was conducted. The incidence of SSI has also decreased over the past decade as per the literature review.[6,7,10-12]

The study found that maternal medical factors such as obesity, GDM, and thrombocytopenia were associated with a higher risk of SSI, but the association with obesity was not statistically significant. The study did not find any association of SSI with hypertension, pre-existing medical illnesses, or anemia. The conflicting relationship with anemia could be explained by sufficient availability of blood and blood components and adequate build-up of patients in the preoperative period, which improves the general condition of the patient, and also good antibiotic coverage, which reduces the rate of bacterial proliferation. Maternal obstetric determinants such as preterm CS, previous CS, preterm pre-labor rupture of membranes, duration of rupture of membranes, and meconium-stained liquor have been found to increase the incidence of SSI as shown by Gomaa *et al*. but this study did not find any such correlation.[13] Chorioamnionitis emerged as a significant risk factor with 8.5 times increased risk of developing SSI. The study also found that patients with prolonged labor (>12 h duration) and multiple per vaginum (PV) examinations (≥5) had significantly higher risk of SSI. Surgery and anesthesia related factors such as use of general anesthesia, emergency procedures compared to electives, vertical skin incision, and general ward stay have been found to increase the risk of developing SSI in other studies, but this study did not find any significant association of rates of infection with these factors.[10,14] Patients with duration of surgery more than 2 h had significant increase in risk of developing SSI. The study also found that patients with post-partum hemorrhage had 3.237 times higher incidence of SSI. The study also evaluated the impact of blood transfusion and antibiotic prophylaxis on the incidence of SSI. Patients who received transfusions were found to have a 2.308 times increased risk of developing SSI, which was statistically significant. Whereas, no significant difference in incidence of SSI was found between the patients receiving antibiotics within or before 60 min of incision.

Clinical spectrum

The study found that the mean time of detection of SSI was 11.75 days and majority of the cases were diagnosed post-removal of sutures. Superficial incisional SSI was more frequent than deep incisional SSI. The most common symptom among patients with SSI was discharge from cesarean site and pain and tenderness were the second most common presentation. SSI increased the duration of hospital stay and some patients even required readmission, daily dressing, prolonged intravenous antibiotics, and re-suturing of the wound. Despite all the morbidity and burden caused by SSI, 100% survival and cure rates were observed.

Antibiotic spectrum

The most frequent isolate was *S. aureus*, followed by other Staphylococcal species and *E. coli*. The study found that linezolid had maximum susceptibility among isolates from patients developing post-CS SSI at GMCH, Chandigarh. Ten out of ten isolates tested for linezolid were susceptible to it. It was followed by doxycycline in seven patients but it is not recommended for use in post-partum patients during lactation.[10] Isolates were found to be resistant to ciprofloxacin, making it the most resistant antimicrobial. The study concluded that further studies are warranted to analyze the associated and especially modifiable risk factors and effect of thrombocytopenia on the risk of SSI as we were not able to find similar findings in literature available from the past few years. It is crucial to identify and modify the risk factors before they are able to impact maternal health negatively. Periodic analysis of the clinical spectrum of SSI and its microbial prevalence with antimicrobial sensitivity patterns is imperative for prompt diagnosis, appropriate empirical management and decelerating the emerging antimicrobial resistance.

CONCLUSION

Post-caesarean surgical site infections (SSI) present a significant challenge, with this study pinpointing risks such as gestational diabetes and thrombocytopenia, etc. Despite GMCH's tertiary care status, a 3.49% SSI incidence is attributed to a comprehensive treatment approach. Staphylococcus aureus prevails, and linezolid is suggested as empirical treatment pending culture results. Continued research should prioritize identifying and modifying risk factors for improved maternal health, stressing routine analysis for timely diagnosis and effective SSI management.

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Ethical approval

The research/study approved by the Institutional Review Board at Government Medical College and Hospital, Chandigarh, number GMCH/IEC/2020/500/133, dated February 24, 2021.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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