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Risk Factors and Bacteriological Profile of Surgical Site Infections Following Cesarean Section: A Single-Center Prospective Cohort Study From Eastern India

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Abstract

Background

Cesarean section (CS) is the most common obstetric surgical procedure performed in reproductive-age women. Subsequently, wound infections following cesarean delivery are on the rise and contribute significantly to increased patient morbidity.

Objectives

This study aimed to ascertain the risk factors associated with surgical site infections (SSIs) in cases following CS. The study also aimed to determine the incidence and bacteriological profile of such post-cesarean wound infections.

Methods

A single-center prospective observational cohort study was conducted in a tertiary referral hospital during October, 2020 to October, 2021. All women who underwent cesarean delivery within the study period were eligible. All cases were followed up for 30 days for development of SSI, if any. Diagnosis of SSI was made based on criteria defined by the National Healthcare Safety Network (NHSN). Swabs were collected from wound discharge of patients with post-cesarean wound infection and sent to the laboratory for culture. The main outcome measures studied were incidence of SSI post-CS, bacteriological profile of SSI, risk factors associated with SSI, and morbidity resulting from it. The statistical significance of the association of risk factors with SSI was analyzed using the chi-square test with Fisher's exact test for categorical variables, and Student's t-test or analysis of variance (ANOVA) for continuous variables.

Results

The incidence of SSI in the study was 9.1% (62 out of 683). The most common organism isolated was *Staphylococcus aureus* in 13/57 (22.8%) cases, followed by *Klebsiella species* in 11/57 (19.3%) cases, and *Escherichia coli* in 11/57 (19.3%) cases. Patient factors such as body mass index (BMI)⩾25 kg/m^2, anemia, and pre-gestational or gestational diabetes significantly increased the risk of SSI post-CS. Obstetric factors such as prolonged rupture of membranes ⩾ 18 hours, previous CS, surgical variables relating to intraoperative blood loss of more than 1000 mL, and duration of surgery ⩾ 1.5 hours were positive risk factors for SSI. The duration of hospital stay in the postoperative period was significantly increased in women with SSI as compared to those without SSI.

Conclusion

Our study provides an overview of the incidence, bacteriological profile, and associated risk factors for SSI post CS in a single-center setting from Eastern India. These findings could help predict and prevent SSI in women undergoing CS, which is an important cause of patient morbidity and a substantial burden on the healthcare system in a developing country.

Categories: Obstetrics/Gynecology, Infectious Disease
Keywords: bacteriology, cesarean section, microbiological profile, postoperative, risk factors, surgical site infection (ssi), wound infection

Introduction

Surgical site infection (SSI) is one of the most common nosocomial infections in hospital settings. SSIs can involve both superficial and deep tissue at the surgical site or even viscera and usually develop within 30

days of surgery [1]. SSIs can have a wide spectrum of presentations ranging from an uncomplicated mild wound discharge to life-threatening sepsis.

Cesarean section (CS) is the most common obstetric surgical procedure performed in reproductive-age women. Subsequently, wound infections following cesarean delivery are on the rise and contribute significantly to increased patient morbidity, particularly in developing countries [1]. Because the rate of infections following operative deliveries is much higher when compared with vaginal deliveries, the length of hospital stay and the economic burden to the healthcare system following CS are also increased in parallel. The incidence of SSI ranges from 3% to 15% with a regional variation according to health resources and accessibility to health care [2,3].

Risk factors attributed to CS wound infections are bacterial contamination of the surgical site, impaired host immune response, long-term steroid use, and body mass index (BMI)>30 kg/m^2 [3]. Uncontrolled diabetes, prolonged labor, prolonged duration of ruptured membranes, anemia, chorioamnionitis, previous cesarean delivery, emergency setting, prolonged duration of surgery, and blood transfusion intraoperatively are determinants of SSI as evidenced from the literature [3-5]. Measures to curb post-surgical wound infections include strict antisepsis, preoperative preparation, and antibiotic prophylaxis, correcting anemia antenatally, achieving glycemic control in diabetics, and prompt management of postpartum hemorrhage [6,7]. Despite advances in surgical procedures, meticulous sterilization of surgical instruments, state-of-the-art surgical techniques, and improved infection prevention practices, SSIs are still a concern in the hospital settings of developing countries [8,9].

SSIs in the postpartum period add to the physical, psychological, and economic burden on the parturient and the woman's family by increasing the duration of hospital stay and the cost of interventions [10]. As postpartum SSI continues to be among the most frequent causes of pregnancy-related maternal morbidity and mortality, there is a need to adopt stringent infection prevention practices, target modifiable risk factors for SSI, and incorporate SSI surveillance systems into standard treatment guidelines to improve patient care [11]. The evidence-based interventions aimed at reducing wound infections are crucial to patient safety and should be incorporated into targeted policies of a state [12]. Because the risk factors and determinants of SSI have regional and ethnic variation, every institute should adopt its own protocol by identifying risk factors specific to the population.

The high incidence rate of SSIs after CS highlights the need for prioritizing SSI control and surveillance in India. However, few data are available on the determinants, characteristics, and incidence of post-CS SSI from tertiary care settings in India. Therefore, this prospective cohort study was carried out to determine the incidence of SSI and identify risk factors and common bacterial pathogens implicated in SSI following CS at a regional referral tertiary care hospital to provide key insights into the management of patients with CS.

Materials And Methods

Study design and ethics approval

A single-center prospective observational cohort study was conducted in a tertiary referral hospital from October, 2020 to October, 2021. The study was approved by the Institutional Ethics Committee. Before informed consent was obtained from all the participants, they were informed about the objectives and design of the study. They were assured that their treatment would not be affected irrespective of their participation in the study, thus ensuring that consent was free. The study methodology and course were in accordance with the ethical standards of the Institutional Ethics Committee and with the Helsinki Declaration of 1975, as revised in 2000.

Study population and eligibility criteria

All women who underwent operative delivery within the study period were eligible for the study. Women who had a CS, irrespective of age, parity, single or multiple pregnancies, elective or emergency CS, or obstetric indications, were eligible for participation in the study. Women who declined informed consent, or presented with SSI after 30 days of lower segment cesarean section (LSCS), were excluded. All COVID-19-positive cases were excluded from the study.

Data were collected in a proforma and recorded at enrolment and at each follow-up. The proforma included demographic data such as age, height, weight, education, and the socioeconomic status. The socioeconomic status was stratified according to the modified Kuppuswamy scale [13]. Obstetric variables such as parity, gestational age, onset and duration of labor, rupture of membranes, and its duration were included. Maternal co-morbidities and medical disorders, if any, such as diabetes, hypertension, anemia, previous CS, and multiple pregnancy, were recorded.

Intraoperative and postoperative variables incorporated were administration of prophylactic antibiotics/ preoperative antibiotics for other conditions, timing of antibiotic prophylaxis, emergency or elective setting of CS, types of uterine incision (lower segment or upper segment), transverse or vertical skin incision, technique of abdominal skin closure (interrupted, subcuticular or stapler), intraoperative blood loss (< 1000

mL or ⩾1000 mL), duration of CS, indication for CS, and length of hospital stay. During hospitalization, the wounds were inspected regularly to check for development of infection, if any. Patients were followed up after discharge till 30 days post-CS. They were called for follow-up visits to the hospital on postoperative Day 14 and Day 30, and the CS wound site was examined. Patients who developed clinical signs of wound infection were either not discharged or readmitted when necessary. The wound swab culture and sensitivity report of patients with SSI were analyzed and recorded in a proforma.

Study definition

Based on the criteria by the Centers for Disease Control and Prevention National Healthcare Safety Network (NHSN) [14], diagnosis of SSI was made within 30 days of CS. The SSIs were classified into three categories. Superficial incisional SSI was characterized by the presence of any one of the following criteria: purulent discharge, isolation of organisms in swab cultures, and the presence of signs and symptoms of infection such as pain or tenderness, localized swelling, redness, or heat. Deep incisional SSI was marked by purulent discharge, wound dehiscence, along with signs or symptoms of fever (>38°C) or localized pain and tenderness. Organ/space SSI was diagnosed when an organism was isolated from endometrial tissue or fluid obtained during the operation along with presence of at least two of the following: fever (>38°C) with other causes excluded, purulent discharge from the uterus and abdominal pain or uterine tenderness; anemia: hemoglobin level less than 11 g/dL; duration of membrane rupture: the time duration from rupture of the membranes (spontaneous or artificial) to skin incision for CS; duration of labor: time duration calculated in hours from the onset of true labor pain to the skin incision for CS; and duration of surgery: duration was calculated from the start of skin incision till skin closure.

Laboratory collection protocol

Swabs were collected from wound discharge of patients with post-cesarean wound infection and sent to the laboratory for culture. Antibiotics were administered only after collection of samples for culture. Proper asepsis was ensured while taking wound swabs from the clinically infected surgical sites. Surgical site surroundings were cleaned with 70% ethyl alcohol to avoid any bacterial contamination.

It was ensured that swabs reached the laboratory for analysis within three hours after collection. Samples were inoculated into appropriate culture media and plates incubated aerobically at 35°C to 37°C for 18 to 24 hours. For anaerobic incubation, plates were kept for 48 hours or longer before opening. Bacterial identification was then done by colony evaluation and secondary tests (Gram staining, biochemical tests, or molecular tests) as deemed appropriate for species verification. Culture plates that showed no bacterial growth after 24 hours of incubation period were termed as sterile/culture negative. However, these culture-negative cases were still included in the cohort of the SSI group.

Sample size calculation

Using the OpenEpi software (AG Dean, KM Sullivan, MM Soe, Atlanta, USA), sample size was calculated. Assuming an expected incidence of SSI of approximately 9%, taking the odds ratio as 3.5 (risk factor for post CS SSI such as anemia and rupture of membranes) [3,10,12], with alpha error of 0.05, power of study 80%, and after correction for 10% attrition, the sample size calculated was 683, which was rounded off to 700.

Outcome variables

The main outcomes studied were incidence of SSI post-CS, bacteriological profile of SSI, risk factors associated with SSI, and morbidity resulting from it. Risk factors pertaining to SSI were grouped into four categories such as women's sociodemographic variables, maternal medical disorders, obstetric variables and operative procedure-related factors. A morbidity variable included was length of hospital stay post-delivery. Age, education and socio-economic status, and body mass index were included in socio-demographic variables. Obstetric variables included parity, gestational age, previous CS, multiple pregnancies, duration of labor, and duration of ruptured membranes. Hypertensive disorders of pregnancy, pre-gestational/gestational diabetes and anemia were the variables studied in the maternal co-morbidities category. Surgical variables included were type of procedure (elective vs. emergency), preoperative antibiotics (single dose prophylaxis vs. multiple doses), type of skin incision, type of uterine incision, skin suturing technique, duration of surgery in minutes, and estimated blood loss during surgery.

Statistical analysis

Data analysis was performed using the Statistical Package for Social Sciences for Windows (SPSS, version 20). Descriptive statistics were used to describe data. The continuous and categorical data were analyzed as mean, standard deviation, proportions or as measures of frequency and percentages where applicable. Association of the potential risk factors with infection was assessed. Categorical variables were analyzed with the chi-square test with Fisher's exact test, and continuous variables were analyzed with Student's t-test or with analysis of variance (ANOVA) where applicable. A p-value of <0.05 was considered statistically significant.

Results

A total of 724 women were screened for eligibility, out of which 700 women met the inclusion criteria for the study, and 24 were excluded. The reason for exclusion were that 15 women did not give consent, 3 underwent re-surgery reasons and 6 presented 30 days after surgery. During the study period, 17 (2.43%) women were lost to follow-up. Thus, 683 women who underwent CS at the tertiary care hospital were followed up for 30 days in the postoperative period. The flow diagram in Figure *1* shows the recruitment process in the prospective cohort study.

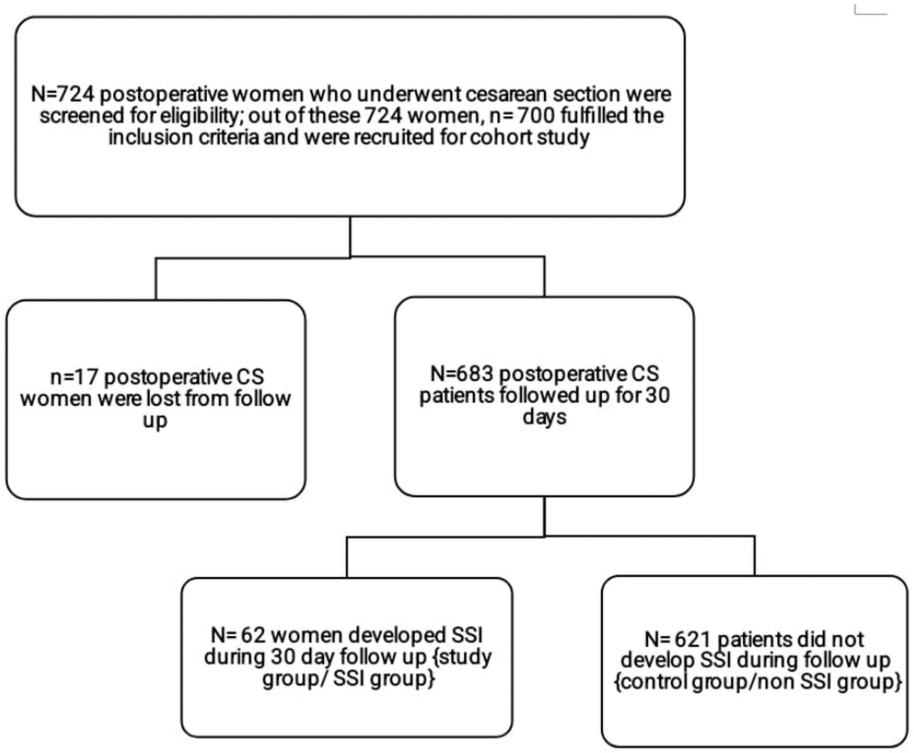


FIGURE 1: Screening, recruitment, and allocation of participants in the cohort study

CS: cesarean section; SSI: surgical site infection

Sixty-two out of 683 (9.1%) women developed SSI; thus, the incidence of SSI in the study was 9.1%. Table *1* shows the SSI characteristics and the bacteriological profile. Pus or swab culture was sent in 57 (91.9%) women, and an organism was isolated in 51 (89.5%) cases. In 6 (10.5%) out of 57 cases, culture report showed no growth or was sterile. It might be attributed to postoperative antibiotics therapy or collection of sample immediately after cleaning of wound by antiseptics solution.

	SSI characteristics	Number (n)	Percentage (%)
Surgical site infection	Yes	62	9.1
	No	621	90.9
Classification of wound infection (n=62)	Superficial	39	62.9
	Deep	20	32.4
	Organ	3	4.8
Pus swab or aspirate sent for culture (n=62)	Yes	57	91.9
	No	5	8.1
Organism isolated from wound (n=57)	*Staphylococcus aureus*	13	22.8
	Coagulase-negative staphylococcus	4	7.0
	Enterococcus species	2	3.5
	Escherichia coli	11	19.3
	Klebsiella species	11	19.3
	Pseudomonas aeruginosa	6	10.5
	Others (*Enterobacter spp., Acinetobacter spp., Proteus vulgaris*)	4	7.0
	Sterile/culture negative	6	10.5

TABLE 1: SSI incidence, classification, and its bacteriological profile

SSI: surgical site infection; spp: species

Table *2* shows the demographic data of women with and without SSI. BMI >25 kg/m ^{2} was found to be significantly associated with increased incidence of SSI. Maternal age, education, and socio-economic status were not linked to the development of post-cesarean wound infection.

Sociodemographic variables		SSI (N=62) Number and percentage		No SSI (N=621) Number and percentage		p-value
Age	18-25	25	(40.32)	223	(35.91)	0.6312
	26-35	28	(45.16)	320	(51.53)	
	>35	9	(14.52)	78	(12.56)	
BMI	<25	50	(80.65)	571	(91.95)	0.006273*
	≥25	12	(19.35)	50	(8.05)	
Education	No formal education	5	(8.06)	62	(9.98)	0.8653
	Primary	18	(29.03)	185	(29.79)	
	Secondary and above	39	(62.90)	374	(60.23)	
Socioeconomic status	Lower class	10	(16.13)	75	(12.08)	0.9040
	Upper lower class	13	(20.97)	150	(24.15)	
	Lower middle class	22	(35.48)	220	(35.43)	
	Upper middle class	11	(17.74)	118	(19.00)	
	Upper class	6	(9.68)	58	(9.34)	

TABLE 2: Sociodemographic data compared between the two groups with and without surgical site infection

*p-value is significant.

SSI: surgical site infection

Table 3 outlines the association of obstetric factors and maternal comorbidities as risk factors for SSI.

Obstetric variables		SSI (n=62) Number and percentage		No SSI (n=621) Number and percentage		p-value
Parity	Primipara	30	48.39	290	46.70	0.4512
	Multipara	32	51.61	331	53.30	
Gestational age	<37 weeks	16	25.81	160	25.76	0.6419
	37-40 weeks	35	56.45	320	51.53	
	>40 weeks	11	17.74	141	22.71	
Duration of labor	Not in labor	18	29.03	161	25.93	0.4911
	<24 hours	38	61.29	420	67.63	
	≥24 hours	6	9.68	40	6.44	
Duration of ruptured membranes (PROM/PPROM)	Intact membranes	20	32.26	175	28.18	0.0000008*
	<18 hours	30	48.39	421	67.79	
	≥18 hours	12	19.35	25	4.03	
Previous cesarean section	Yes	20	32.26	130	20.93	0.03273*
	No	42	67.74	491	79.07	
Multiple pregnancy	Yes	5	8.06	35	5.64	0.2930
	No	57	91.94	586	94.36	
Hypertensive disorders of pregnancy	Yes	19	30.65	155	24.96	0.2023
	No	43	69.35	466	75.04	
Pre-gestational/gestational diabetes	Yes	9	14.52	30	4.83	0.00554*
	No	53	85.48	591	95.17	
Anemia (hemoglobin<11 g/dL)	Yes	50	80.65	420	67.63	0.02169*
	No	12	19.35	201	32.37	

TABLE 3: Association of obstetric variables and maternal co-morbid conditions with SSI

*p-value is significant.

PROM: premature rupture of membranes; PPROM: preterm premature rupture of membranes

The association of surgical variables with development of SSI is demonstrated in Table *4*. The mean length of hospital stay postoperatively in the SSI group was 11.36 ± 3.76 days, while the mean length in the non-SSI group was 5.46 ± 2.34 days. The difference between the two means was found to be statistically significant.

Perioperative variables		SSI (n=62) Number and percentage		No SSI (n=621) Number and percentage		p-value
Type of CS	Emergency (N=600)	52	83.87	548	88.24	0.2069
	Elective (N=83)	10	16.13	73	11.76	
Preoperative antibiotics	Prophylactic single dose	50	80.65	536	86.31	0.1519
	Multiple doses	12	19.35	85	13.69	
Type of skin incision	Transverse	58	93.55	600	96.62	0.1839
	Vertical	4	6.45	21	3.38	
Skin suturing	Interrupted	40	64.52	387	62.32	0.8118
	Subcuticular	12	19.35	142	22.87	
	Stapler	10	16.13	92	14.81	
Type of uterine incision	Lower segment	59	95.16	611	98.39	0.1056
	Classical	3	4.84	10	1.61	
Intra-operative blood loss	<1000 mL	48	77.42	560	90.18	0.0043*
	≥1000 mL	14	22.58	61	9.82	
Duration of surgery	<1.5 hours	44	70.97	540	86.96	0.0014*
	≥1.5 hours	18	29.03	81	13.04	

TABLE 4: Study of surgical variables in cases with and without SSI

*p-value is significant.

SSI: surgical site infection

Discussion

With the advent of stringent maternal and fetal monitoring tools in modern obstetrics, the incidence of cesarean delivery is on the rise. SSI is an important outcome indicator after CS. In this prospective cohort study, we assessed the incidence, risk factors, and bacteriological profile of SSIs post-CS in a tertiary care center. The incidence of SSIs in our study was 9.1% (62 out of 683). A similar incidence rate was reported in another prospective study [15]. In several other studies, the prevalence of SSI was recorded to be higher, ranging from 16.01% to 18.8% [16,17], whereas a Kenyan study [4] reported a prevalence of 2.1%, which was much lower than our study. The incidence of postoperative infections from various Indian studies varied from 10 to 25% [12,18]. The rates from developed world varies between 2% to 8%, which is much lower when compared to the rates of the developing countries [19].

The most common category of SSI was superficial incisional type, accounting for 39 (62.9%) cases. In another Indian study and studies from Africa [4,10,15,20], superficial SSI was the most common, accounting for approximately 60-70% of cases, followed by deep incisional SSI (~30%). Skin flora contamination and micro-trauma from suture points make the skin and the subcutaneous tissue more vulnerable to infection as compared to deeper fascial and muscular layer, which benefit from protective anatomic barriers and secure closure in well-vascularized planes [21,22]. The most common organism isolated was *Staphylococcus aureus* in 13 cases (22.8%), followed by *Klebsiella* species in 11 cases (19.3%) and *Escherichia coli* in 11 cases (19.3%). The microbiological profile in another study from Kosovo revealed *S. aureus* in 28.1% of the isolates, *Enterococcus faecalis* in 15.6%, and *E. coli* isolated in 9.4% [15]. Gupta et al. observed *methicillin-sensitive S. aureus* in 42% of their isolates, followed by *Klebsiella* in 24% [10]. *E. faecalis* and *E. coli* were the most common pathogens identified in a retrospective analysis from China [23].

There is no clear association of socio-demographic factors with SSI. An increased risk of post-surgical wound infection has been observed with advanced maternal age [15]. However, our study found no significant association with age. Pre-gestational obesity and pre-existing psychiatric conditions were independent risk factors for SSI [17,24]. Our study also showed obese women (BMI ⩾25 kg/m^2) to be more likely to develop SSI. Education and socioeconomic class were not associated with SSI development.

Incidence of SSI was not affected by parity and gestational age [25]; this finding was in concordance with our study. Duration of labor was linked to SSI with a 1.37-fold to 3-fold increase in risk [26]; contributing factors could be longer duration of ruptured membranes with risk of ascending infection, multiple vaginal examinations, obstructed labor ending in emergency CS, and chorioamnionitis. However, our study found no association between duration of labor and SSI post-LSCS, which was similar to the findings from an African retrospective study by Odada et al [4]. Among obstetric factors, duration of ruptured membranes ⩾18 hours and previous CS were associated with increased risk of wound infection post-CS.

Maternal medical co-morbidities such as maternal anemia and diabetes mellitus (pre-gestational/gestational) impair neutrophil phagocytic action, delay wound healing, and block local immune response, making the incision site more vulnerable to bacterial colonization, thus substantially increasing the odds of post-cesarean SSI [12,26]. However, an Indian study did not show any significant association of diabetes mellitus or preeclampsia with the development of SSI [10]. Hypertensive disorder of pregnancy was found to have no increased risk of SSI in our study too.

A major outcome of this study was the association between intraoperative blood loss ⩾1000 mL and SSI. Substantial blood loss is linked to compromised tissue perfusion and oxygenation, prolonged surgery, and tissue trauma [5]. Type of CS (emergency or elective), classical or LSCS, was not linked to SSI in our study. The reason could be the universal administration of prophylactic antibiotics and optimal asepsis. Vertical or transverse skin incision and the technique of skin suturing posed no risk for SSI, which was similar to our study [27]. Prolonged duration of surgery ⩾1.5 hours was associated with increased risk for SSI in many studies, which concur with our study [12,27]. The finding relates to the antibiotic metabolism and clinical kinetics of the drug, with a decline in peak blood levels that occurs in prolonged surgeries [18]. Multiple doses of antibiotics preoperatively did not have protective effect over single-dose prophylactic antibiotics in preventing SSI.

The duration of hospital stay in the postoperative period was significantly increased in women with SSI in comparison to those without SSI, subsequently increasing the cost of hospitalization. The hospital duration is extended between 6 and 19 days depending on the type of infection and the health care setting. Deep SSIs and organ-space SSIs require significantly longer treatment duration, surgical debridement, and re-suturing compared to superficial skin infections [28]. A large proportion of (approximately 49% to 66%) SSIs were diagnosed post-discharge leading to readmissions and longer total hospital stays combined with initial stays [29].

The limitations of our study were small sample size and it being a single-center study. A larger sample size involving multi-center studies from different regions of the country could add more to the evidence and impact healthcare system surveillance. Moreover, multivariate regression analysis was not done, which could have addressed the confounding variables, if any. Collaborative studies would allow for an extensive and diverse study population and enhance generalizability of findings while identifying risk factors that could aid in formulating preventive measures in management of SSIs.

Conclusions

Our study provides an overview of the incidence, bacteriological profile, and associated risk factors for SSI post-CS in a single-center setting in Eastern India. Based on our study results, it was concluded that patient factors like BMI⩾25 kg/m^2, anemia, and pre-gestational or gestational diabetes increased the risk of SSI post-CS. Obstetric factors such as prolonged rupture of membranes ⩾ 18 hours, previous CS, and surgical variables relating to intraoperative blood loss of more than 1000 mL and duration of surgery ⩾ 1.5 hours were positive risk factors for SSI. The duration of hospital stay in the postoperative period was significantly increased in the SSI group as compared to the group without SSI. Identification and optimization of comorbid conditions and controlling intraoperative blood loss can result in subsequent reduction of SSI rates. We speculate these findings could help predict and prevent SSI in women undergoing CS, which is an important cause of patient morbidity and a substantial burden on the health care system in a developing country.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Vandana Mohapatra, Sibabrata Kar, Manoja Bhuyan

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Drafting of the manuscript: Vandana Mohapatra, Manoja Bhuyan

Critical review of the manuscript for important intellectual content: Vandana Mohapatra, Sibabrata

Kar, Manoja Bhuyan

Supervision: Sibabrata Kar

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Institutional Ethics Committee, Fakir Mohan Medical College & Hospital, Balasore issued approval 35/IEC dated 18.08.2020. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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