

Risk Factors for Surgical Site Infection after Cesarean Section in a Multinational Population

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Abstract

Background: Surgical site infections (SSIs) are the most frequent healthcare-associated infections worldwide. Identifying risk factors is a key priority to focus prevention efforts, reduce their incidence, and improve patient safety.

Objectives: We aim to identify the risk factors for SSI in patients from various nationalities cared for in Qatar.

Methods: A nested case-control study was conducted at a community hospital in Dukhan, Qatar.

Results: One hundred and twenty-six patients from 45 nationalities were included in the study, with 42 SSI cases. The risk of SSI was 3.48 times greater when non-compliance with the timing of antibiotic prophylaxis was documented, 9.69 times for improper antibiotic selection, and the risk decreased by 63% for each postoperative consultation.

Conclusion: The study has identified key risk factors for SSI and areas for prevention and research in patients who underwent cesarean section.

Keywords: Cesarean Section, Risk Factors, Surgical Site Infection, Nested Case-Control, Qatar

1. Background

Surgical site infection (SSI) after a cesarean section (CS) is an adverse outcome closely related to the quality of healthcare and has a significant impact on morbidity and cost. The rate of SSI varies according to different studies, reaching up to 15%.¹⁻⁴ A study conducted in Saudi Arabia reported an incidence of 4.2%,⁵ while a single facility in Qatar had a 2.53% SSI rate.⁶

Multiple factors are related to the incidence of SSIs, including those related to patients (e.g., age, comorbidities), procedures (e.g., complexity, degree of contamination of the surgical site, duration), as well as compliance with prevention practices, among others, are highlighted.⁷⁻⁹ In (CS), various specific SSI risk factors have been identified, including prolonged labor, prolonged rupture of membranes, presence of anemia, presence of chorioamnionitis, presence of meconium, vertical skin incision, greater than 2 cm thickness of subcutaneous tissue, and general anesthesia.⁵

The prophylactic use of antibiotics is one of the basic prevention practices that has an undesirable level of compliance according to published literature. Previous experiences have shown improvements in the quality of antibiotic prescription through multidimensional interventions, including staff education, monitoring, and feedback,

among others.¹⁰⁻¹⁴

In Hamad Medical Corporation (Doha, Qatar), surveillance of healthcare-associated infections has been carried out in a standardized manner for over a decade, which is conducted by qualified personnel in infection control and guided by a corporate program.

2. Objectives

Limited studies have been published on the risk factors for SSIs after CS in Qatar. This study aims to identify the risk factors for SSIs in patients who underwent CS at The Cuban Hospital.

3. Methods

A case-control study was nested within a cohort of 1349 women who underwent CS from 01/09/2016 to 02/28/2023 at The Cuban Hospital, Dukhan (Qatar). These patients represent all CS performed during that period.

The Cuban Hospital is one of the four public healthcare facilities in Qatar where CS are performed. Patients requiring a CS represent the overall pregnant women in the country, taking into account demographics, living location, and clinical characteristics.

The maternity service performs 300-400 CSs per year.

The following data were collected: age, surgical procedure duration, wound type (clean-contaminated, contaminated, dirty), American Society of Anesthesiologists score (ASA score), and compliance with antibiotic prophylaxis. Antibiotic prophylaxis was considered adequate if cefazolin or clindamycin (0.9 g) was administered 15 to 60 minutes before incision, or vancomycin (1 g) within 2 hours of the incision. The dose of cefazolin was adjusted according to the patient's weight with 1-2 g in patients weighing less than 120 kg, and up to 3 g in patients weighing 120 kg or more. Additional doses are recommended in selected situations including bleeding, and contamination of the surgical site.

In addition to previously collected data, clinical data (comorbidities, previous parity and CSs, body mass index) and procedural data (number of vaginal examinations, premature rupture of membranes, duration of urinary catheterization, number of preoperative and postoperative consultations with the surgical team, CS category, and laboratory tests on admission (hemoglobin, serum albumin, preoperative and postoperative glycemia) related to the SSI risk were collected from electronic medical records.

CSs are classified into four categories. The first category involves situations where a CS is required as it poses an immediate threat to maternal or fetal life, such as cord prolapse or suspected uterine rupture. The second category includes cases where there is maternal or fetal compromise but it is not immediately life-threatening, such as malpresentation of the fetus in active labor or failure to progress. The third category involves a need for early birth but no maternal or fetal compromise, such as planned CS in early labor. The fourth category involves arranging a CS at a convenient time for both the woman and the CS team, such as in cases of failed induction.

The cases considered are patients who underwent a CS and were confirmed with SSI within the 30-day postoperative period. Controls were selected from patients who underwent a CS during the study period and did not report any SSI within the 30-day postoperative period. Additionally, no wound conditions such as hematoma, cellulitis, or seroma were reported, and surgical site infection was ruled out.

For each identified case, 2 controls were randomly selected from the list of patients included in the cohort. The controls were selected using the MedCalc random number generator (<http://www.medcalc.org/manual/generaterandomsample.php>).

SSI was confirmed using the CDC definitions as per the corporate infection control program.^{15,16} Post-discharge surveillance was conducted by reviewing the electronic medical records of cases and controls 30 days after the surgical procedure. Additional information about the surveillance methodology can be found in the paper published with the cohort data.⁶

3.1. Statistical Analysis

The statistical technique of frequency distribution was used for initial data analysis. Subsequently, in the qualitative variables, the homogeneity test was used to test the null hypothesis H_0 of equality of the distribution of the different variables in cases (women with SSI) and controls (women without SSI). For quantitative variables, the non-parametric Wilcoxon-Mann-Whitney test was used for the same purpose, to compare the means of the different variables between cases and controls. The logistic regression technique was used. The model included the independent variables: number of previous deliveries, timing of antibiotic prophylaxis, antibiotic selection, and number of postoperative consultations, with the occurrence of SSI as the response variable. Collinearity between the independent variables was tested, and a variable was considered independently associated with SSI occurrence when the 95% confidence interval of the odds ratio did not include unity as one of the possible values. For the hypothesis tests that were carried out, a significance level $\alpha = 0.05$ was set.

4. Results

One hundred and twenty-six patients were included in the study, with a mean age of 31 years (standard deviation 5.0). 29.4% had a history of diabetes mellitus, 7.9% had arterial hypertension, and 6.3% had hypothyroidism. Regarding nutritional status, 59.5% of women were obese, 28.6% were overweight, and 0.8% were underweight. Patients were from 45 nationalities, mainly from Middle Eastern countries and the Indian Subcontinent, with the majority living in Qatar as expatriates.

SSIs were reported in 42 patients, with 35 of them having superficial incisional infections, 4 deep incisional infections, and 3 organ space infections (Table 1). The number of previous deliveries, compliance with timing, selection, and dose of antibiotic prophylaxis, and the number of postoperative consultations were the variables related to SSI ($P < 0.05$). The mean number of deliveries was higher in patients with SSI (2.76) compared to patients without SSI (2.11), and the number of patients with ≥ 3 deliveries was greater in the case group (52.4%) compared to controls (32.1%). The appropriate timing of antibiotic prophylaxis was higher in controls (91.7%) compared to cases where compliance was lower (76.2%). Similarly, compliance with selection and dose was higher in controls (98.8%) than in cases (88.1%). The mean number of postoperative consultations was higher in controls (1.02) than in cases (0.76). No statistical differences were observed for the other variables between cases and controls.

Table 2 presents the results of the logistic regression analysis. The variables: timing, selection, and dose of antibiotic prophylaxis, and the number of postoperative consultations were found to be independently associated

Table 1. Characteristics of Patients in the Case and Control Groups Undergoing CS

Variables		Control	Case	P value
Age, mean (SD), years		31.16(5.15)	30.71 (4.63)	0.695
	20-26 years	19 (22.6%)	8 (19.0%)	0.289
	27-34 years	40 (47.6%)	26 (61.9%)	
Comorbidities	35-43 years	25 (29.8%)	8 (19.0%)	
	Diabetes mellitus	23 (27.4%)	14 (13.3%)	0.628
	High Blood pressure	6 (7.1%)	4 (9.5%)	0.907
Parity, mean (SD)	Hypothyroidism	7 (8.3%)	1 (2.4%)	0.366
		2.11 (1.29)	2.76 (1.62)	0.033
	< 3	57 (67.9%)	20 (47.6%)	0.045
Previous CS, mean (SD), number	≥ 3	27 (32.1%)	22 (52.4%)	
		0.59 (0.83)	0.74 (0.93)	0.396
	< 2	74 (88.1%)	35 (83.3%)	0.645
Cesarean section category	≥ 2	10 (11.9%)	7 (16.7%)	
	1	8 (9.5%)	7 (16.7%)	0.137
	2	31 (36.9%)	19 (45.2%)	
	3	7 (8.3%)	0	
BMI (kg/m2)	4	38 (45.2%)	16 (38.1%)	
	< 19.8	0	1 (2.4%)	0.41
	19.8-26.0	10 (11.9%)	4 (9.5%)	
	26.1-29.0	26 (31.0%)	10 (23.8%)	
Procedure duration, mean (SD), minutes	≥ 29	48 (57.1%)	27 (64.3%)	
		44.7 (8.93)	42.61 (10.28)	0.142
	20-39 min	28 (33.3%)	20 (47.6%)	0.201
	40-55 min	46 (54.8%)	16 (38.1%)	
ASA score	56-69min	10 (11.9%)	6 (14.3%)	
	1	2 (2.4%)	0	0.278
	2	73 (86.9%)	34 (81.0%)	
	3	9 (10.7%)	8 (19.0%)	
Timing of AP, mean (SD), minutes		21.89 (6.14)	20.33 (8.71)	0.206
	1-14 minutes	7 (8.3)	9 (21.4)	0.072
	15-37 minutes	77 (91.7)	33 (78.6)	
	timing correct	77 (91.7%)	32 (76.2%)	0.034
Selection/dose of AP	Correct selection y doses	83 (98.8%)	37 (88.1%)	0.027
Discontinuation of AP	Timely discontinuation	84 (100%)	40 (95.2%)	0.208
Vaginal examination	number (mean (SD))	1.23 (1.57)	1.59 (1.69)	0.256
Premature rupture of membranes (RPM)	RPM documented	58 (69.0%)	24 (57.1%)	0.261
Urinary catheterization	RPM time, mean (SD), hrs	2.35 (5.64)	2.27 (3.55)	0.472
	duration, mean (SD), hrs	23.96 (1.59)	23.57 (2.59)	0.974
Lab test	Hb, mean (SD), g/dl	11.72 (1.64)	11.81 (1.32)	0.645
	Serum albumin, mean (SD), g/L	34.28 (4.36)	33.58 (4.27)	0.29
	Serum glycemia, mean (SD), mmol/L	4.81 (0.77)	4.89 (0.88)	0.691
	Postop glycemia, mean (SD), mmol/L	5.73 (1.32)	5.59 (1.07)	0.594
Preoperative consultations, mean (SD), number		4.02 (1.64)	3.38 (2.06)	0.067
	< 3 consultations	20 (23.8%)	15 (35.7%)	0.232
	≥ 3 consultations	64 (76.2%)	27 (64.3%)	
Postoperative consultations, mean (SD), number		1.02 (0.51)	0.76 (0.62)	0.009
	< 3 consultations	83 (98.8%)	42 (100%)	1.00
	≥ 3 consultations	1 (1.2%)	0	

Data presented as No (%) unless specified, SD: Standard deviation; AP: Antibiotic prophylaxis; CS: Cesarean Section; Hb: Hemoglobin.

Table 2. Odds Ratio and 95% Confidence Interval of SSI in Patients Undergoing CS

Variable	OR	IC 95% OR
Number of previous deliveries	1.21	0.90 – 1.63
Timing of antibiotic prophylaxis		
Incorrect	3.48	1.12 – 10.77
Correct*	1	---
Selection and dose of antibiotic prophylaxis		
Incorrect	9.69	1.01 – 92.85
Correct*	1	---
Postoperative consultations	0.37	0.16 – 0.86

* Category of reference

with SSI. The probability of SSI is 3.48 times greater when non-compliance with the timing of antibiotic prophylaxis was documented (OR = 3.48; 95% CI = 1.12-10.77). Improper selection and dose increase the SSI risk by 9.69 times (95% CI = 1.01-92.85), and regarding postoperative consultations, the probability of SSI occurrence decreases by 63% for each consultation that the patient attends during the post-operative period (OR =

0.37; 95% CI = 0.16-0.86). The number of previous deliveries was not associated with the SSI risk.

5. Discussion

The study identified independent risk factors for SSI after CS, including improper antibiotic prophylaxis (timing, selection, and dose) and a reduced number of post-operative consultations.

The timely administration of antibiotic prophylaxis is an evidence-based prevention practice. According to corporate policy, the administration of cefazolin or clindamycin within 15-60 minutes before surgical procedures is recommended. For methicillin-resistant *Staphylococcus aureus* colonized patients, the combination of cefazolin plus vancomycin is recommended. In the study, patients who received the antibiotic within 15 minutes before the skin incision had a higher SSI risk. Besides, the improper selection, mainly in COVID-19 patients, and the subtherapeutic dose of cefazolin (in obese women) or clindamycin were identified. The failure to provide the proper antibiotic prophylaxis has been systematically identified as a key risk factor for SSI in CS.¹⁶⁻¹⁸ Also, interventions aimed at improving compliance have shown significant effects in reducing SSI incidence.^{19,20}

Critical elements for the prevention of adverse outcomes during pregnancy include compliance with preoperative and postoperative standards of care.¹⁹⁻²² In our environment, patients' care is often reported during the final stages of their pregnancy without previous consultations recorded at the facility, indicating that these patients were likely followed by primary care. Similarly, after discharge, patients did not return for follow-up by the attending obstetrician during the 30 days post-CS. In both the pre- and post-CS periods, there are important actions for preventing surgical site infections, including patient education, methicillin-resistant *Staphylococcus aureus* screening, proper hair removal practices, and various recommendations for postoperative wound care and monitoring early signs of infection. The contribution of postoperative factors, particularly improper wound care, is not well defined in CS.^{23,24} A previous observational study conducted in the same facility, including data from CS procedures performed over 10 years, revealed a few elements linking some SSI cases to improper wound care, particularly in patients with a longer time from the CS procedure until evidence of SSI occurs.⁶

The reduced number of postoperative consultations and the risk of SSI should be considered a key area for improvement in infection prevention. This should focus on patient education, wound care, and early detection of infections.

The study has several limitations. It was carried out in a single center, which limits the generalizability of the findings. The potential comparability of patient populations is also a limitation, even though the patients studied could be representative of pregnant women throughout the population in Qatar. Moreover, the study included COVID-19 cases, which may have differences in risk factors related to the viral infection. Other patient and care factors, not included in the study, could explain the infection risk, including the diagnosis of chorioamnionitis, preoperative hair removal practices, and cultural issues

related to post-delivery care in a multinational population of patients.

6. Conclusion

The study has identified compliance with antibiotic prophylaxis and reduced postoperative consultations as risk factors independently associated with SSI risk in patients undergoing CS. Additional studies are required to identify additional risk factors and assess the effectiveness of preventive measures.

Research Highlights

What Is Already Known?

- Surgical site infection is a frequently reported adverse patient outcome in healthcare facilities.
- The risk of surgical site infection in cesarean sections is higher compared to other procedures.

What Does This Study Add?

The study identifies risk factors for surgical site infection in a multinational population in Qatar, focusing on antibiotic prophylaxis, and providing insight to strengthen the prevention program.

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Author Contributions

Study design: HGG; Data acquisition: HGG, RMDR, TSE, YMF, OMG, and TMFH; Data analysis: HGG, RMDR, TSE, YMF, OMG, TMFH, and FGG; Manuscript writing: HGG and FGG; Critical review and major scientific input: HGG, RMDR, TSE, YMF, OMG, TMFH, and FGG.

Conflict of Interest Disclosures

All authors declared that they have no conflict of interest.

Ethical Approval

The study was approved by The Medical Research Center (Hamad Medical Corporation, Doha, Qatar) with MRC-01-23-649.

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