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Original Research Article

Factors associated with superficial surgical site infection after emergency cesarean section at Befelatanana University Hospital, Madagascar: a retrospective case-control study

Rasoanandrianina Bienvenue Solange[1]*, Ramanantoanina Andriamiangola[1], Razanabao Tsirava Elissa[2], Razafimanantsoa Annick[3], Randriamahavonjy Romuald[1], Andrianampanalinarivo Hery Rakotovao[1]

[1]Department of Medicine, University of Antananarivo, Madagascar
[2]Department of Obstetrics and Gynecology, Centre Hospitalier de Référence Régional (CHRR), Manakara, Madagascar
[3]Department of Obstetrics and Gynecology, Centre Hospitalier de Dax, Dax, France

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***Correspondence:**
Dr. Rasoanandrianina Bienvenue Solange,
E-mail: rbienvenuesolange@yahoo.com

ABSTRACT

Background: Surgical site infection (SSI) after emergency cesarean section is a preventable cause of maternal morbidity and additional cost, especially in resource-limited maternity hospitals. This study aimed to identify factors associated with superficial incisional SSI after emergency cesarean section at the University Hospital of Gynecology and Obstetrics of Befelatanana, Madagascar.
Methods: A retrospective case-control study was conducted from January 2020 to December 2021. Cases were women treated for superficial incisional SSI within 30 days after emergency cesarean section at term. Controls were women without SSI, selected at a ratio of two controls per case. Data were extracted from hospital records, antenatal cards, registers and interviews. Odds ratios (ORs), 95% confidence intervals (CIs) and p values were calculated.
Results: Among 12,708 deliveries, 4,857 were cesarean sections, including 3,897 emergency procedures. Sixty superficial SSIs were identified, giving a frequency of 1.5%; 120 controls were included. Factors significantly associated with SSI were age ≥35 years, absence of antenatal care, BMI ≥25 kg/m^2, premature rupture of membranes, membrane rupture ≥12 hours, labour ≥12 hours, operation duration ≥60 minutes, blood loss ≥1000 ml and operation by a specialist trainee.
Conclusions: Superficial SSI after emergency cesarean section was multifactorial. Strengthening antenatal care, timely labour management, optimized antibiotic prophylaxis, senior supervision, infection-prevention bundles and post-discharge wound surveillance may reduce post-cesarean SSI in this setting.

Keywords: Cesarean section, Emergency obstetric surgery, Madagascar, Risk factors, Superficial incisional infection, Surgical site infection

INTRODUCTION

Cesarean section is one of the most frequently performed obstetric operations and is essential for reducing maternal and perinatal mortality when medically indicated.[1] Its increasing use, however, exposes more women to postoperative complications, including surgical site infection (SSI), which remains one of the most common and preventable causes of postoperative maternal morbidity.[1-5] In 2023, a global systematic review reported wide variation in post-cesarean SSI incidence across regions, with higher rates in low- and middle-income settings.[5]

Superficial incisional SSI is generally defined as infection occurring within 30 days after surgery and involving only the skin and subcutaneous tissue of the incision.[1,2] It may present with localized pain, tenderness, swelling, warmth, erythema, purulent discharge or opening of the wound by a clinician when infection is suspected.[1] Although less severe than deep or organ-space infection, it leads to repeated dressings, antibiotic use, additional consultations, delayed recovery, reduced ability to care for the newborn and avoidable costs.[3,6]

Emergency cesarean section is a particularly high-risk situation because it is often preceded by prolonged labour, repeated vaginal examinations, ruptured membranes, meconium-stained or infected amniotic fluid, maternal exhaustion, anaemia or haemorrhage.[6-12] Recent African data confirm that prolonged rupture of membranes, prolonged labour, chorioamnionitis, high body mass index and absence of preoperative antibiotics are recurrent risk factors for post-cesarean SSI.[6,13-15] Therefore, local surveillance is necessary because the distribution of risk factors and the feasibility of preventive interventions vary between hospitals.[2,3,6]

At the University Hospital of Gynecology and Obstetrics of Befelatanana (CHUGOB), cesarean section represented 38.0% of deliveries during the 2020-2021 study period, and most operations were performed as emergencies. This study was conducted to identify factors associated with superficial incisional SSI after emergency cesarean section at CHUGOB and to provide evidence for locally applicable prevention strategies.

METHODS

Study design and setting

This was an analytical retrospective case-control study conducted at the University Hospital of Gynecology and Obstetrics of Befelatanana (CHUGOB), a public tertiary referral centre in Antananarivo, Madagascar. CHUGOB provides obstetric and gynaecological care and serves as a teaching and research hospital. The source population included all parturients who delivered at CHUGOB from January 2020 to December 2021. Data collection and analysis were conducted from January to November 2023.

Participants

Cases were women managed for superficial incisional SSI after emergency cesarean section performed at or beyond 37 weeks of amenorrhoea. Women were eligible as cases if they presented either during hospitalization or after discharge within 30 days of the cesarean section. Controls were women who underwent emergency cesarean section at or beyond 37 weeks during the same period and did not develop SSI. Controls were selected after inclusion of the cases, with two controls for each case. Incomplete medical records were excluded in both groups. Women with postoperative infections other than superficial wound suppuration were excluded to maintain a homogeneous case definition.

Data sources and variables

Data were collected from delivery and theatre registers, medical records, antenatal care cards and patient interviews when required. A standardized data extraction form was used. Maternal variables included age, education level, gravidity, parity, number of antenatal care (ANC) visits, body mass index (BMI) and mode of admission. Intrapartum variables included premature rupture of membranes (PROM), duration of membrane rupture, amniotic fluid appearance and labour duration. Operative variables included antibiotic prophylaxis, type of anaesthesia, duration of operation, estimated blood loss and qualification of the operator. BMI was categorized as <18, 18-25 and ≥25 kg/m^2. Labour and membrane rupture durations were dichotomized at 12 hours, and operative duration was categorized as ≤30 minutes, 30-60 minutes or ≥60 minutes.

Outcome definition

The outcome was superficial incisional SSI occurring within 30 days after emergency cesarean section. Diagnosis was based on clinical features documented in the medical record or during postoperative review, including localized pain, tenderness, swelling, warmth, erythema, purulent discharge from the superficial incision or opening of the wound for suspected superficial infection.1 Bacteriological confirmation was not required because microbiological data were not consistently available in routine practice during the study period.

Statistical analysis

Data were entered in Microsoft Excel and analysed using Epi Info version 7. Descriptive statistics were used to summarize maternal and obstetric characteristics. Associations between potential risk factors and superficial SSI were estimated using odds ratios (ORs) with 95% confidence intervals (CIs). A p value less than 0.05 was considered statistically significant. An OR greater than 1 was interpreted as a risk factor and an OR less than 1 as a protective association. Because the study was retrospective and based on available records, no imputation was performed for missing variables; incomplete records were excluded according to the protocol.

Ethical considerations

Patient confidentiality and professional secrecy were respected throughout the study. Each record was identified by a study number. Data collection sheets were kept securely, and the electronic database was stored on a password-protected computer. The study used routinely collected clinical information and did not include any intervention affecting patient care.

RESULTS

During the study period, 19,906 admissions and 12,708 deliveries were recorded at CHUGOB. Vaginal delivery accounted for 7,851 births, while 4,857 deliveries were by cesarean section, corresponding to a cesarean section rate of 38.0%. Among the cesarean sections, 3,897 were emergency procedures and 960 were planned procedures. Sixty women developed superficial incisional SSI after emergency cesarean section and were included as cases; 120 women without SSI were included as controls. The frequency of superficial SSI among emergency cesarean sections was therefore 1.5% (Figure 1).

The mean age of women with superficial SSI was 28.2±6.9 years, with extremes of 17 and 46 years. Age ≥35 years was significantly associated with superficial SSI (29 cases versus 29 controls; OR 2.93, 95% CI 1.52-5.56; p=0.001). In contrast, age 20-35 years appeared protective (OR 0.52, 95% CI 0.27-0.98; p=0.02), while age ≤20 years was not significantly associated with SSI (OR 0.67, 95% CI 0.29-1.46; p=0.09).

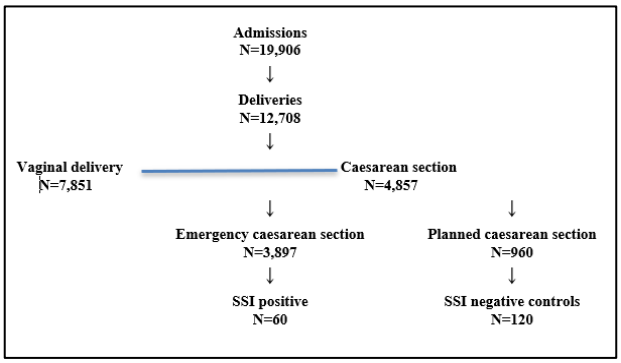

Figure 1: Study flow chart and frequency of superficial surgical site infection after emergency cesarean section.

SSI, surgical site infection. Frequency of superficial SSI among emergency cesarean sections: 60/3,897 = 1.5%.

Table 1: Distribution of patients according to epidemiological and clinical profiles.

Variable	Modality	SSI +	SSI -	OR (95% CI)	P value
Age (in years)	≤20	10	28	0.67 (0.29-1.46)	0.09
	20-35	21	63	0.52 (0.27-0.98)	0.02
	≥35	29	29	2.93 (1.52-5.56)	0.001
Education	Primary	0	20	-	0.00008
	Secondary	25	34	1.80 (0.94-3.45)	0.03
	High school	25	48	1.07 (0.57-2.01)	0.41
	University	10	18	1.13 (0.43-2.63)	0.38
Gravidity	Primigravida	12	24	1.10 (0.51-2.39)	0.47
	Paucigravida	32	62	1.06 (0.57-1.98)	0.47
	Multigravida	16	34	0.89 (0.44-1.80)	0.45
Parity	Primipara	15	34	0.84 (0.41-1.70)	0.38
	Paucipara	40	76	1.15 (0.60-2.22)	0.39
	Multipara	5	10	1.00 (0.32-8.06)	0.60
ANC visits	None	34	32	3.50 (1.87-6.89)	0.00008
	1-3	6	28	0.36 (0.14-0.93)	0.02
	4-7	20	60	0.50 (0.26-0.95)	0.02
BMI	<18 kg/m^2	3	13	0.43 (0.11-1.58)	0.15
	18-25 kg/m^2	35	87	0.53 (0.27-1.01)	0.04
	≥25 kg/m^2	22	20	2.00 (1.23-5.04)	0.0008
Admission mode	Referred	29	68	0.71 (0.38-1.33)	0.18
	Direct	31	52	1.39 (0.75-2.60)	0.18

Gravidity and parity were not significantly associated with superficial SSI. Antenatal care showed a strong association: women with no antenatal visits had higher odds of SSI (34 cases versus 32 controls; OR 3.50, 95% CI 1.87-6.89; p=0.00008). Having one to three antenatal visits or four to seven visits was associated with lower odds of SSI. BMI≥25 kg/m^2 was associated with increased odds of SSI (OR 2.00, 95% CI 1.23-5.04; p=0.0008), whereas BMI 18-25 kg/m^2 was associated with lower odds. Mode of admission was not significantly associated with SSI (Table 1).

Intrapartum factors were strongly associated with infection. PROM was present in 36 cases and 30 controls and was associated with markedly increased odds of SSI (OR 4.50, 95% CI 2.32-8.71; p=0.000005). Duration of membrane rupture ≥12 hours was also associated with SSI (OR 2.50, 95% CI 1.36-4.93; p=0.002). Meconium-stained amniotic fluid was associated with increased odds of superficial SSI (OR 2.00, 95% CI 0.99-4.02; p=0.02). Labour duration ≥12 hours was one of the strongest intrapartum associations (OR 3.80, 95% CI 1.96-7.64; p=0.000007) (Table 2).

Table 2: Distribution of patients according to labour-related factors.

Variables	Modality	SSI +	SSI -	OR (95% CI)	P value
PROM	Yes	36	30	4.50 (2.32-8.71)	0.000005
	No	24	90	0.22 (0.11-0.43)	0.000005
Duration of membrane rupture	<12 hours	29	85	0.38 (0.20-0.73)	0.002
	≥12 hours	31	35	2.50 (1.36-4.93)	0.002
Amniotic fluid colour	Clear	19	34	1.17 (0.59-2.29)	0.38
	Meconium-stained	20	24	2.00 (0.99-4.02)	0.02
	Pea-soup fluid	21	62	0.79 (0.41-1.53)	0.30
Duration of labour	<12 hours	29	88	0.25 (0.13-0.50)	0.000001
	≥12 hours	31	32	3.80 (1.96-7.64)	0.000007

Table 3: Distribution of patients according to intervention-related factors.

Variables	Modality	SSI +	SSI -	OR (95% CI)	P value
Antibiotic prophylaxis	Yes	59	120	0	0.33
	No	1	0	-	0.33
Type of anesthesia	Spinal anesthesia	40	74	1.24 (0.64-2.38)	0.31
	General anesthesia	20	44	0.86 (0.44-1.65)	0.39
	Epidural anesthesia	0	2	0	0.44
Duration of operation	≤30 minutes	0	2	-	-
	30-60 minutes	25	83	0.64 (0.31-1.33)	0.15
	≥60 minutes	35	35	3.00 (1.78-6.47)	0.0001
Blood loss	≥1000 ml	43	52	3.30 (1.69-6.44)	0.0002
	<1000 ml	17	68	0.31 (0.15-0.58)	0.28
Operator qualification	Specialist physician	2	24	0.13 (0.03-0.60)	0.0007
	Assistant physician	13	36	0.64 (0.31-1.33)	0.15
	Specialist trainee	45	60	3.00 (1.54-6.07)	0.0007

SSI- surgical site infection; OR- odds ratio; CI- confidence interval; ANC- antenatal care; BMI- body mass index; PROM- premature rupture of membranes.

Most women received intraoperative antibiotic prophylaxis: 59 of 60 cases and all 120 controls had documented prophylaxis. Because only one woman did not receive prophylaxis, no meaningful association could be demonstrated. Type of anaesthesia was not significantly associated with SSI. Operative duration ≥60 minutes was associated with SSI (35 cases versus 35 controls; OR 3.00, 95% CI 1.78-6.47; p=0.0001), and estimated blood loss ≥1000 ml increased the odds of SSI (OR 3.30, 95% CI 1.69-6.44; p=0.0002). Regarding operator qualification, operation by a specialist trainee was associated with higher odds of SSI (OR 3.00, 95% CI 1.54-6.07; p=0.0007), whereas operation by a specialist appeared protective (OR 0.13, 95% CI 0.03-0.60; p=0.0007) (Table 3).

DISCUSSION

This study found a frequency of superficial incisional SSI of 1.5% among emergency cesarean sections at CHUGOB. This proportion is lower than the pooled African estimate reported in a 2025 systematic review and lower than several prospective studies from sub-Saharan Africa, where post-cesarean SSI rates often exceed 7%.[6,12,15] The difference may reflect the restriction of the present study to superficial incisional infections, routine antibiotic prophylaxis, and under-ascertainment after discharge because the design was retrospective.[1,6,7]

Advanced maternal age was associated with SSI in our study. Women aged 35 years or more had almost three times the odds of infection. Similar observations have been reported in post-cesarean SSI studies in which older age was a marker of comorbidity, reduced tissue healing capacity and more complicated obstetric histories.[5,15] Because maternal age is not modifiable, it should be used as a risk marker to reinforce preventive measures rather than as an isolated determinant of care.

The absence of antenatal care was one of the strongest maternal factors associated with SSI. Antenatal care allows screening and treatment of anaemia, malnutrition, diabetes, hypertension, genital infection and urinary infection, all of which may influence postoperative recovery.[3,16] Recent studies from Ethiopia and Uganda have also linked limited antenatal follow-up, unstable referral status or delayed presentation with increased post-cesarean infectious morbidity.[13,15] In the CHUGOB context, improving the quality of peripheral antenatal care and referral may therefore reduce postoperative infection, not only obstetric complications before delivery.

BMI≥25 kg/m^2 was associated with SSI in this series. Excess adipose tissue increases incision depth, tissue handling, dead space, wound tension and operative difficulty; it is also relatively poorly vascularized, which may reduce oxygen delivery and local antibiotic concentration.[7-11] These mechanisms explain why high BMI has been repeatedly identified as a risk factor for post-cesarean wound complications.[6,17] Preventive strategies in overweight women should include weight-based antibiotic dosing when appropriate, meticulous haemostasis, careful subcutaneous tissue management, reduced tissue trauma and scheduled wound review.[9-11]

PROM, rupture duration ≥12 hours and labour duration ≥12 hours were strongly associated with superficial SSI. Once membranes rupture, ascending microorganisms from the lower genital tract can contaminate the amniotic cavity and the operative field.[6,12,17] Prolonged labour can be accompanied by repeated vaginal examinations, maternal exhaustion, tissue oedema, obstructed labour and delayed decision-making, all of which increase wound contamination and impaired healing.[6,14,15] These findings are consistent with African meta-analytic data showing PROM and prolonged labour among the most frequently reported risk factors for SSI after cesarean section.[6]

Meconium-stained fluid was associated with SSI in the present dataset. This finding should be interpreted as a marker of complicated labour, fetal stress or intra-amniotic inflammation rather than as an isolated causal factor.[6,15] In practice, meconium-stained fluid during emergency cesarean section should alert the team to the possibility of prolonged labour, contamination and need for careful operative and postoperative infection-prevention measures.

Antibiotic prophylaxis was almost universal in this study, limiting statistical evaluation of its protective effect. Strong evidence supports prophylactic antibiotics for cesarean section, and current recommendations generally favour administration before skin incision.[7-9] Adjunctive azithromycin has been shown to reduce infection among women undergoing non-elective cesarean delivery in selected settings, but local use should consider antimicrobial stewardship and resistance patterns.[18] Since SSI persisted despite routine prophylaxis, CHUGOB should re-evaluate antibiotic timing, molecule, dose adjustment for BMI, and additional coverage in prolonged rupture of membranes, ideally with microbiology and pharmacy input.[3,19]

Operation duration ≥60 minutes and blood loss ≥1000 ml were significantly associated with SSI. Longer operations increase tissue exposure to the theatre environment and often reflect surgical complexity, adhesions, haemorrhage or technical difficulty.[7,10,12] Major blood loss may lead to anaemia, hypoperfusion and reduced tissue oxygenation, compromising immune response and wound healing.[11,20] Therefore, timely senior assistance, good surgical exposure, efficient haemostasis, availability of uterotonics and haemorrhage-management protocols are important infection-prevention measures as well as safety measures.

Operator qualification was associated with SSI, with specialist trainees having higher odds and specialists appearing protective. This does not mean that training should be reduced; CHUGOB is a university hospital and operative teaching is essential. Rather, the result suggests that emergency cesarean section is a high-risk learning environment where structured supervision, checklists and standardized surgical steps may improve safety while preserving training quality.[2,3] Senior involvement may also reduce operative time and blood loss in complex cases.

Recent literature also emphasizes antimicrobial resistance as an emerging concern in post-cesarean infections. A 2025 Ethiopian study documented multidrug-resistant organisms among post-cesarean wound isolates, highlighting the need for local bacteriological surveillance.[19] Although the present study focused on clinical superficial SSI, future CHUGOB surveillance should include wound cultures when feasible to guide empiric treatment and update prophylaxis protocols.

The practical implication is that SSI prevention after emergency cesarean section should not be limited to the operating theatre. A feasible prevention bundle at CHUGOB could include improved antenatal screening, early treatment of genital and urinary infections, prevention and correction of anaemia, partograph-based labour monitoring, avoidance of unnecessary vaginal examinations, timely decision-making, optimized antibiotic prophylaxis, alcohol-based skin antisepsis, surgical hand preparation, glove change before wound closure, dedicated closure instruments and structured post-discharge wound surveillance.[3,9,10,21,22]

This study has limitations. It was monocentric and conducted in a tertiary referral centre, which limits generalizability to other Malagasy hospitals. The retrospective design may have missed post-discharge infections and depended on record completeness. Bacteriological results were rarely available, preventing analysis of causative organisms and resistance patterns. Several potential confounders, including diabetes, anaemia, hypertension, number of vaginal examinations and exact antibiotic timing, were not consistently documented. Multivariable adjustment was not performed, so some associations may be confounded. Despite these limitations, the findings are clinically coherent and identify actionable points across antenatal, intrapartum, operative and postoperative care.

CONCLUSION

Superficial surgical site infection after emergency cesarean section at CHUGOB was a multifactorial complication involving maternal characteristics, quality of antenatal follow-up, intrapartum events and operative factors. Significant risk factors included age ≥35 years,

absence of antenatal care, BMI≥25 kg/m^2, PROM, rupture of membranes for at least 12 hours, labour lasting at least 12 hours, operative duration at least 60 minutes, blood loss of at least 1000 ml and operation by a specialist trainee. Protective factors included absence of PROM, rupture duration less than 12 hours and labour duration less than 12 hours.

The findings support a comprehensive prevention strategy starting before delivery and continuing after discharge. Strengthening antenatal care, improving intrapartum monitoring, avoiding prolonged rupture and prolonged labour when possible, ensuring senior supervision of emergency cesarean sections, optimizing antibiotic prophylaxis and reinforcing aseptic practice may reduce post-cesarean SSI and improve maternal recovery in this setting. Future prospective studies with post-discharge follow-up and microbiological documentation are needed to refine prevention protocols and address antimicrobial resistance.

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