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Clinical Study

Risk Factor Analysis and Microbial Etiology of Surgical Site Infections following Lower Segment Caesarean Section

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Background. Lower segment caesarean section (LSCS) is a common mode of delivery now and surgical site infection is the second most common infectious complication in these patients. This study was planned with this background to have a comprehensive approach to SSI following LSCS. *Methods*. 500 consecutive patients undergoing LSCS, irrespective of indication, were studied. A questionnaire was developed to assess the risk factors associated with development of SSI. All patients were followed up from day one of surgery till discharge and then up till the postoperative day 30 after discharge. *Results*. SSI was identified in 121 (24.2%) out of 500 patients. In all age groups, Gram-negative bacilli were the commonest finding. The commonest isolate was *Acinetobacter* species (32.03%) followed by *Staphylococcus aureus* and coagulase negative *Staphylococcus* (21.09%). 23.8% of *Staphylococcus aureus* strains were MRSA. By multivariate logistic regression premature rupture of membrane (PROM), antibiotics given earlier than 2 hours and increased duration of stay in the hospital were found to be significant. *Conclusions*. A proper assessment of risk factors that predispose to SSI and their modification may help in reduction of SSI rates. Also, frequent antimicrobial audit and qualitative research could give an insight into the current antibiotic prescription practices and the factors affecting these practices.

1. Introduction

Surgical site infection (SSI) is a common, generic postoperative event that causes considerable morbidity but seldom leads to death. Surveillance of SSI is an important infection control activity [1]. Most of the studies on surgical site infections in lower segment caesarean section patients have been conducted outside India. As a result not much data is available on the incidence rates of SSI following lower segment cesarean section (LSCS) in Indian hospitals. The data is also lacking in the knowledge of common pathogens after LSCS. There exists a need to investigate intraoperative and postoperative risk factors for SSI after LSCS. In spite of the availability of antibiotics, SSIs are still responsible for much morbidity and far reaching socioeconomic consequences for both patients as well as health care systems. Reduction in surgical site infections while minimizing antibiotic resistance still remains a challenge for many health care institutions.

2. Materials and Methods

The study was carried out prospectively in the Department of Microbiology and Department of Obstetrics and Gynaecology, Lady Hardinge Medical College and Smt. Sucheta Kriplani Hospital, New Delhi, from November 2008 to March 2010. The study protocol was approved by institutional ethical committee.

2.1. Study Area and Study Population. 500 consecutive patients undergoing emergency/elective LSCS were included in the study irrespective of the indication. At this hospital more than 10,000 deliveries are conducted in a year. SSI rate has been found to be between 15 and 20% by institutional infection control team. Assuming 15% as the basic percentage of development of surgical site infections in postcaesarean patients requesting a 95% confidence interval for the proportion with width no higher than 15% and power of 90%, the minimum sample size needed is 491. A conservative estimate gave a minimum sample size as 500. The patients were assessed postoperatively. Informed consent was taken from every patient enrolled in the study. None of the patients declined to be part of the study. Surgical wound was inspected at the time of first dressing and daily thereafter till discharge of the patient and then all patients were followed up in postnatal clinic till the 30th postoperative day. All patients who developed SSI following surgery were included as cases. All patients who underwent LSCS but did not develop SSI after 30 days were included in the control group. Data was collected from every patient regarding the various risk factors and demographic details by means of a detailed questionnaire.

Surgical site infection was detected on the basis of the criteria given in the modified CDC definition, 1992 [1].

2.2. Microbiological Methods. Purulent discharge was collected from the surgical incision site 48 hours postoperatively with sterile cotton swabs. Thereafter sample was collected every 48 hours till the patient was discharged. Blood sample for blood culture was collected as and when the possibility of septicemia or bacteremia as suggested by the presence of fever, shock, or other signs and symptoms of sepsis associated with the surgical wound was taken a note of. The bacterial isolates obtained were identified as per standard identification procedures [2].

Antibiotic susceptibility of the incriminated organism was done using standard disc diffusion method as per Clinical Laboratory Standards Institute (CLSI) guidelines [3].

Data was recorded on a predesigned study questionnaire and managed on an excel spreadsheet. Quantitative variables were assessed for approximate normal distribution and summarized as mean and standard deviation. Categorical variables were summarized by frequency (percentage). Association of each of the potential risk factors with infection as the study outcome was assessed using Pearson's chi-square test. Comparison of quantitative data was done through Student's t-test (equivalent to z-test for large samples). The multivariate logistic regression with Forward-LR model selection criteria was used to assess the significant prognostic factors responsible for infection. SPSS version 12.0 statistical software was used for data analysis. In this study, all the inferences were obtained at 5% level of significance and hence P value < 0.05 has been considered as statistically significant.

3. Results

500 patients included in the study were in the age group 18 years to more than 30 years. The mean age of patients who underwent LSCS was 25.42 ± 3.68 years. Majority of the patients (50.8%) were in the age group 21–25 years, followed by those in the age group of 26–30 years (35.2%). Only 40 (8%) were more than 30 years of age, while 6% of the patients were in the age group of 18–20 years. No patient was found to be less than 18 years. 417 (83.4%) out of 500 women underwent emergency LSCS while only 83 (16.6%) women underwent elective surgery.

102 patients out of 500 were found to have infection at the surgical site during their stay in the hospital within 7 days of surgery. 19 patients with surgical site infection were detected by postdischarge surveillance. Thus SSIs were identified in 121 (24.2%) women who underwent LSCS. Table 1 lists the distribution of various pathogens causing SSI. A total of 128 bacterial isolates were obtained from 121 cases. Seven (5.78%) SSIs had a polymicrobial etiology. *Acinetobacter* Spp. was the most common isolate (32.03%) followed by *Escherichia coli* and *Klebsiella* species which were responsible for 18.75% and 14.8% of SSIs, respectively. Other Gram-negative organisms isolated were *Citrobacter freundii*, *Proteus vulgaris*, and *Pseudomonas aeruginosa*. Among the Gram-positive organisms, *Staphylococcus aureus* was the most common isolate (16.4%) followed by coagulase negative *Staphylococcus* (4.68%) and *Enterococcus* species (3.12%). Antimicrobial resistance pattern of these organisms is shown in Tables 2(a) and 2(b).

Table 1: Isolation of various pathogens causing surgical site infections.

Organisms isolated	Number
Staphylococcus aureus	21 (16.4%)
Coagulase negative *Staphylococcus*	6 (4.68%)
Enterococcus spp.	4 (3.12%)
Escherichia coli	24 (18.75%)
Klebsiella spp.	19 (14.8%)
Citrobacter freundii	4 (3.12%)
Proteus vulgaris	1 (0.78%)
Pseudomonas aeruginosa	8 (6.25%)
Acinetobacter spp.	41 (32.03%)
Total isolates	128

Risk Factor Analysis. Risk factors showing a significant association ($P < 0.05$) were increasing age, emergency procedure, body mass index more than 25, anemia, prolonged preoperative hospital stay, prolonged total duration of surgery and that of hospital stay, vertical skin incision, premature or prolonged rupture of membranes (more than 24 hours), failure of timely antibiotic prophylaxis (within 30 minutes of skin incision), preexisting medical illness, and intraoperative blood transfusion. The risk factor analysis is shown in Table 3.

By multivariate logistic regression premature rupture of membrane (PROM), antibiotics given earlier than 2 hours and increased duration of stay in the hospital were found to be significant. It was interpreted that PROM > 24 hrs is likely to increase the chances of infection by 182.9% (odds ratio = 2.829, P value = 0.017). Also antibiotic given before 2 hrs is likely to increase the chance of infection by 850.5% (odds ratio = 9.505, P value < 0.001) and as the duration of hospital stay increases by 1 day, the chances of infection increase by 151.3% (odds ratio = 2.513, P value < 0.001).

4. Discussion

Besides increase in morbidity and mortality, nosocomial infections prolong the hospital stay of patients and increase bed occupancy rate. Also, 7–12% of hospitalized patients end

Table 2: (a) Resistance pattern in Gram-positive organisms (in %). (b) Resistance pattern in Gram-negative organisms (in %).

(a)

Org.	V	P	M	E	At	C	T	G	Co	Cp	Cu	Ac	Am
S. aureus	0	66.7	23.8	15.8	14.28	66.67	28.6	25	44.4	56.25	64.3	35.7	46.7
Enterococcus spp.	0	50	—	100	0	0	0	66.7	50	100	0	0%	0
CONS	0	16.6	—	0	16.67	0	0	0	0	60	100	60	66.67

V: vancomycin, P: penicillin, E: erythromycin, At: azithromycin, C: chloramphenicol, T: tetracycline, G: gentamicin, Co: cotrimoxazole, Cp: cephalexin, Ac: amoxicillin-clavulanic acid, and Am: amoxicillin.

(b)

Org.	Ak	Cf	Ci	Ce	Co	As	A	I	Ac	Nt	Sc	Pb	Ca	Ao
E. coli	14.28	12.5	20.8	14.28	61.9	50	64.7	0	38.5	33.3	0	0	0	60
Kleb. spp.	16.67	16.67	33.3	0	72.2	5.5	—	0	0	0	0	0	0	0
C. freundii	25	0	75	0	50	0	66.7	0	0	0	0	0	0	0
P. vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	100	100
Ps. aeruginosa	0	14.28	14.28	100	0	0	0	0	0	0	0	0	0	0
Acineto. spp.	36.58	31.7	68.29	81.8	67.6	9.3	91.67	0	0	0	9	20	18.7	50

Ak: amikacin, Cf: ciprofloxacin, Ci: ceftriaxone, Co: cotrimoxazole, As: ampicillin-sulbactam, A: ampicillin, I: imipenem, Ac: amoxicillin-clavulanic acid, Nt: netilmicin, Sc: sparfloxacin, Pb: polymyxin b, Ca: ceftazidime, and Ao: aztreonam.

Table 3: Risk factor analysis of surgical site infections following LSCS.

Risk factor present	SSI present (out of 121)	SSI absent (out of 379)	*P* value
Emergency procedure	96 (79.3)	319 (84.1)	<0.05
BMI > 25	21 (17.3)	17 (4.5)	<0.05
Prolonged preop. hospital stay (3.11 ± 4.05 days)	17 (14.1)	34 (8.9)	<0.05
Prolonged total duration of stay after surgery (13.08 ± 4.71 days)	8 (6.6)	7 (1.8)	<0.05
Vertical skin incision	24 (19.8)	28 (7.4)	<0.05
PROM > 24 hrs (22.94 ± 2.4 hrs)	31 (25.6)	48 (12.7)	<0.05
Failure of timely antibiotic prophylaxis	71 (58.7)	40 (10.5)	<0.05
Preexisting medical illness	5 (4.1)	4 (1.1)	<0.05
Intraoperative blood transfusion	17 (14)	30 (7.9)	<0.05
Hb < 11 g% (10.43 ± 2.4)	52 (43)	121 (31.9)	>0.05
P/V > 3	33 (27.2)	112 (29.5)	>0.05
General anaesthesia	3 (2.5)	4 (1)	>0.05

P value < 0.05 taken significant.

up with hospital acquired infections globally with more than 1.4 million people suffering from infectious complications acquired in the hospital [4]. Surgical site infection is an important outcome indicator after surgery. The situation is worsened by the emergence of polymicrobial resistant strains of nosocomial pathogens [5].

The infection rate in the present study was 24.2% including postdischarge surveillance and compares favorably with other reported rates ranging from 2.5 to 41.9% [6–10]. In India, the incidence of postoperative infections in various hospitals varies from 10 to 25% [7, 8, 10]. Majority of these infections (48.76%) were identified in the age group 21–25 years. All SSIs were found to be superficial and limited to stitch line. No deep infections were found. As shown in Table 4.

The incidence of caesarean section has dramatically increased in modern medicine and is attributed to many maternal and fetal factors. In the present study, out of 500 patients, 83.4% women underwent emergency LSCS and the rest were electively operated. Emergency LSCS predisposes more to SSI as compared to elective surgery [11–13]. In the present study a similar observation was made. Out of 121 patients who were infected, 80.16% of the patients were those who had undergone emergency procedure. In emergency caesarean the membranes may have ruptured or home delivery may have been attempted. Also, there might be any preexisting condition or complication or increased exogenous bacterial contamination or breaks in sterile technique or lack of timely antibiotic prophylaxis. Similar findings have been reported by Martens et al. also [14]. All these factors could have resulted in higher rates of infection.

Body mass index of more than 25 has been shown to affect the outcome of surgery [13, 15, 16]. The local changes such as increase in adipose tissue, a need for larger incision, decreased circulation to fat tissue, and an increase in local tissue trauma related to retraction contribute to an increased

Table 4: Multivariate logistic regression of significant risk factors.

	Variables in the equation					95.0% C.I. for odds ratio	
		B	S.E.	P value	Odds ratio	Lower	Upper
Step 1[a]	Duration_Hospital_Stay	0.563	0.056	0.000	1.757	1.574	1.960
	Constant	−6.320	0.529	0.000	0.002		
Step 2[b]	Duration_Hospital_Stay	1.034	0.105	0.000	2.814	2.291	3.456
	Preop_Stay_2(1)	−5.892	0.890	0.000	0.003	0.000	0.016
	Constant	−9.766	0.853	0.000	0.000		
Step 3[c]	Antibiotic_2(1)	2.246	0.371	0.000	9.448	4.564	19.559
	Duration_Hospital_Stay	0.917	0.102	0.000	2.501	2.049	3.053
	Preop_Stay_2(1)	−5.626	0.923	0.000	0.004	0.001	0.022
	Constant	−9.516	0.860	0.000	0.000		
Step 4[d]	PROM_24 hrs(1)	1.040	0.434	0.017	2.829	1.209	6.621
	Antibiotic_2(1)	2.252	0.379	0.000	9.525	4.525	19.964
	Duration_Hospital_Stay	0.922	0.102	0.000	2.513	2.058	3.069
	Preop_Stay_2(1)	−5.837	0.946	0.000	0.003	0.000	0.019
	Constant	−9.757	0.883	0.000	0.000		

[a]Variable(s) entered on step 1: Duration_Hospital_Stay.
[b]Variable(s) entered on step 2: Preop_Stay_2.
[c]Variable(s) entered on step 3: Antibiotic_2.
[d]Variable(s) entered on step 4: PROM_24 hrs.

incidence of SSI in these patients [17, 18]. Independent factors related to body homeostatic balance which take place in wound healing and immune function are disturbed in such patients. In the present study an increased BMI was seen to influence the outcome of surgery in terms of an increased rate of infection.

Patients with anaemia were seen to be more prone to SSI. Anaemia diminishes resistance to infection and is frequently associated with puerperal sepsis. Preoperative anaemia is an important predictor of infection and has been proved by several other studies [16, 19, 20]. In our study also, anaemia was found to be significantly associated with SSI.

Premature rupture of membranes is associated with the largest bacterial inoculum and liquor gets infected and infection supervenes [21]. 39.2% of patients who had a premature rupture of membranes or prolonged rupture (for more than 24 hours before surgery) were subsequently infected. It was found to be a significant risk factor in the study as was reported by several other authors [13, 22, 23]. Multivariate analysis also supported this finding.

The surgeon may choose either a vertical or a transverse skin incision. Vertical incision may be infraumbilical midline or paramedian. Transverse, modified Pfannenstiel incision is made 3 cm above the symphysis pubis. A transverse incision has less chance of wound dehiscence [23]. In our study univariate analysis indicated that type of skin incision has been significantly associated with SSI. This compares favorably with other reports [22, 24].

Antibiotic prophylaxis in surgical patients has always been a matter of debate. For prophylactic antibiotic the current recommendation states that the parenteral antibiotic must be given within 2 hours of incision so as to attain high tissue and serum levels during surgery [25]. However at many centres prophylactic antibiotics have been withheld until after the umbilical cord has been clamped. In our hospital, antibiotics are administered at rupture of membranes or 30 minutes before incision. As per hospital antibiotic policy the antibiotics administered include ampicillin (500 mg), metronidazole (500 mg), and gentamicin (80 mg). Patients who received antibiotics 2 hours before surgery were found to be less prone to SSI as compared to those who did not receive it in a timely fashion. This association was found to be statistically significant which is in accordance with other studies [23, 26, 27].

Shapiro et al. reported that with each hour of surgery the infection rate almost doubles [28]. The finding relates to the pharmacokinetics of the antibiotic prophylaxis and to the greater bacterial wound contamination that occurs in lengthy clean-contaminated surgeries. In the present study, 53.3% of patients with prolonged duration of surgery exceeding 45 minutes got infected which was found to be statistically significant. Lilani et al. reported a rate of 38.46% for surgeries that lasted more than 2 hours [29]. Johnson et al. classified duration of LSCS into ≤ 30 minutes and 31–60 minutes and found an increased rate of SSI in the latter group [30]. Several other studies have reported similar findings [6, 23, 31].

A prolonged preoperative stay with exposure to hospital environment, its ubiquitous diagnostic procedures, therapies, and microflora, including multidrug resistant organisms, have been shown to increase the rate of SSI [32]. Kowli et al. found an infection rate of 17.4% when preoperative stay was 0–7 days and an infection rate of 71.4% with preoperative stay of more than 21 days [10]. Anvikar et al. in their study demonstrated an infection rate of 1.76% when preoperative stay was up to one day, which increased to 5% when preoperative stay was more than one week [6]. In the present study, significant correlation was found between the duration of preoperative hospital stay and development of SSI.

Several studies have reported an increased SSI rate in patients operated under general anaesthesia as compared to patients operated under regional anaesthesia [30, 33]. In our study only 7 cases were operated under general anaesthesia. In such low numbers, association could not be established.

Patients with multiple per vaginal examinations were not seen to be more predisposed to SSI and were contradictory to studies that have proved this association [20]. An explanation to the above could be that all such patients had received a timely antibiotic prophylaxis.

Lilani et al. found that mean postoperative stay of patients who developed infection was almost 4 times (24.82 days) as compared to patients who did not develop SSI, where mean postoperative stay was 6.19 days [29]. Our study also found similar results. Patients with SSI had a mean postoperative period of 13.08 ± 4.7 days as compared to that of 7.5 ± 2.08 days in case of uninfected patients.

Patients with preexisting illnesses like diabetes mellitus, bronchial asthma, and jaundice or immunocompromised status were seen to be more prone to infection in the present study. Hyperglycaemia has several deleterious effects upon host immune function, most notably on neutrophil function. Poor control of glucose during surgery and in the perioperative period increases the risk of infection and worsens outcome from sepsis. Hypertension, preexisting or pregnancy induced, HIV, and other comorbid states have been associated with SSI in several studies [13, 21, 34, 35]. They are associated with low vitality and thus predispose to infection [21]. They were all seen to influence the outcome in the present study.

The relationship between blood products and SSIs has been a matter of debate for more than two decades. Several studies have supported the association between the use of blood products and the development of postoperative surgical site infections. Allogeneic blood products have immunomodulatory effects that may increase the risk of nosocomial infections [36, 37]. It is also possible that the transfusion of blood products acts as a marker for individuals with a greater number of comorbidities and other SSI risk factors, which independently places them at an inherently greater risk for infection. The patients who had received blood transfusion in our study were also seen to be more predisposed to SSI.

Common causative organisms leading to post-LSCS SSI include Gram-negative bacteria, anaerobes, and *Staphylococcus aureus* [38]. In our study, the most frequently isolated organism was *Acinetobacter* species (32.03%). This is in contrast to NNIS service survey (1997–2001) that reported *Staphylococcus aureus* (47%) including MRSA and *Staphylococcus epidermidis* (CONS) as the most common organism causing SSI [39]. Many other studies have reported similar findings of predominance of *Staphylococcus aureus* in wound infections [8, 29, 31]. In our study, *Acinetobacter* species was frequently isolated from the operation theatre environment and this could have resulted in contamination of the wound edges at the time of surgery. The isolates had a similar antimicrobial susceptibility pattern as those isolated from the wound site. Also, an outbreak was reported during the period of study due to *Acinetobacter* spp. and was effectively controlled by infection control team, but this has probably led to the higher prevalence of this organism from our SSI.

Staphylococcus aureus and *Staphylococcus epidermidis* (CONS) were found to be the second most frequently isolated group of organisms (22.3%).

Polymicrobial etiology was found in 7 out of 121 SSIs identified. Lilani et al. found a polymicrobial etiology in 2 out of 7 SSIs. One of the most prevalent bacteria isolated was *Staphylococcus aureus*. Special interest in *Staphylococcus aureus* SSI is due to its role in hospital infection and emergence of virulent antibiotic resistant strains. 66.67% of *S. aureus* strains were found to be resistant to penicillin. Ineffectiveness of penicillin in *S. aureus* has been reported in other studies also [28, 29]. 23.8% of strains were MRSA. MRSA infections are of great concern due to high morbidity and mortality rates. The other major concern in SSIs is that *S. aureus* originates from patients' nasal flora and may influence the outcome of surgery [24]. The increased isolation rates of *S. aureus* stress the need to screen and treat subjects for nasal carriage which could possibly influence etiology of SSIs.

5. Conclusion

To conclude a proper assessment of risk factors that predispose to SSI and their modification may help in reduction of SSI rates. Also, frequent antimicrobial audit and qualitative research could give an insight into the current antibiotic prescription practices and the factors affecting these practices.

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