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FROM AROUND THE GLOBE

Prevalence and predictors of wound infection in elective clean and clean/contaminated surgery in Khartoum Teaching Hospital, Sudan

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Abstract
Surgical site infections are the second most common cause of hospital acquired infections. The objectives of this study were to quantify the rate of wound infection and to identify risk factors associated for its prevalence among patients admitted for elective surgery in Khartoum Teaching Hospital in Sudan. A prospective study was conducted. All patients, aged >18 years admitted during March 1st 2010 to 31th October 2010 were recruited. Baseline data was collected before the patient was operated. Patients were followed up to one month for detection of wound infection using bedside and post-discharge surveillance. A total of 1387 patients were included with a mean age of 35±14 years and 1138(82%) were females. More than three quarters were healthy (79.3%) and 1367 (98.6%) patients were operated on conventionally. The total number of the performed surgical procedures was 1426. The rate of wound infection was found to be 9%. The majority of the infected wounds 120 (96%) were superficial and only 5 (4%) were deep incisional. Univariate analysis revealed that five variables were significantly associated with the prevalence of wound infection; namely patient's body mass index (P=0.041), co-morbidity (P=0.006), presence of diabetes (P=0.010), ASA score (P<0.0001) and laparoscopic surgical technique (P=0.007). Multivariate logistic analysis showed that ASA score 2 and ASA score > 3, [adjusted OR 1.9 (1.2-3.0), P =0.006 and adjusted OR 3.6 (2.0-6.7); P<0.001 respectively], laparoscopic surgical technique [adjusted OR 5.5 (2-14.8); P=0.001] were mostly significantly associated with the prevalence of wound infection. The rate of wound infection was high with patient's physical status being strong predictor of infection.

Key words
Surgical wound infection+epidemiology+prevention and control; risk factors; Sudan; Surgical procedures, elective

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Introduction

Surgical site infection (SSI) is increasingly recognized as a measure of the quality of patient care by both healthcare providers and the public.[1] SSIs are the second most common cause of hospital acquired infections.[2] Incisional infections are controlled easily; however deeper and more extensive infections may have devastating consequences.[3] The occurrence of such infections increases the length of hospital stay, admission to the intensive care unit, incidence of readmission and risk of mortality.[4]

Many factors influence the rate of infection; these factors can be categorized into those that arise from patient's health status, those related to the physical environment where surgical care is provided and those resulting from clinical interventions that increase the patient inherent risk.[5]

The most commonly identified patient-related factors are pre-existing diabetes and/or preoperative hyperglycemia, obesity or malnutrition, pre-existing remote body site infection, recent tobacco use, contaminated or dirty wound, colonization with microorganisms, and preoperative hypothermia.[6]

The identification of the risk factors allows elucidation of those that are modifiable from those that are not and helps in the development of interventional strategies to reduce the risk of infection.[7]

The main objectives of this study were to quantify the rate of wound infection and to identify the risk factors associated for its prevalence among patients admitted for elective clean and clean- contaminated procedures.

Hospital

The study was conducted in Khartoum Teaching Hospital in Sudan which was established in 1904. The hospital is currently a thousand bed tertiary referral hospital. It covers all the major specialities including medicine, surgery, obstetrics and gynaecology, urology, psychiatry, paediatric surgery and orthopaedics.

Methods

Study design

A prospective study was conducted; whereby all adult patients whose ages were ≥18 years old admitted for elective clean and clean-contaminated surgical procedures were recruited prospectively. Emergent surgical procedures were excluded due to the limited financial and human resources available for the conduction of the research. The procedures were distributed among three departments: General Surgery, Obstetrics and Gynaecology and Urology. Patient was excluded in the presence of one or more of the following criteria: use of antibiotic/s for non prophylactic purposes on the same day of surgery or the patient had antibiotic/s and stopped it 48 hours before surgery, principal diagnosis suggestive of a preoperative infectious disease, procedure involving the insertion of an implant, surgical procedure that did not involve incision, patient already recruited in the study and again scheduled for surgery during the study period, patient refused to participate in the study, patients that did not complete the follow up period, and patient died before completion of one month period after surgery.

Sample size

A total of 1387 patients were included during the period 1st March to 31st October 2010.

Data collection

Data was collected in real time by trained nurses using a pre-coded questionnaire. The data was obtained either directly from the patient, or by observations or from the patient's file. The following data were recorded: gender, age/year, dates of admission, surgery and discharge, body mass index and presence of co-morbidities. The American Society of Anesthesiologists score (ASA score)[8] was recorded as (1= healthy, 2= mild systemic disease, 3= severe systemic disease, 4= life threatening disease and 5= moribund), surgical discipline, grade of operator (surgeon, registrars, medical officer & house officers), surgical technique (classic versus laparoscopic technique), wound class (clean versus clean-contaminated), name of operation, category of operation, duration of operation in hours, and the use of surgical drain were also documented. A section in the questionnaire was designed to collect data on wound infection (occurrence, when detected during admission or after discharge and clinical signs).

Wound infection was detected by two methods: Bedside and post-discharge surveillance. Bedside surveillance involved following the patient during hospital admission and started from the day after surgery until the patient was discharged from the hospital. Post-discharge surveillance was conducted by phoning the patients for up to 3 telephone calls during a period of one month after discharge. A trained nurse asked each patient structured questions about the presence of any sign/s of wound infection. Wound infection definition and diagnosis was based on the criteria of the Center of Disease Control (CDC)[9] except for the duration of surgery that was defined as <1hour and ≥1 hour.

Outcomes & Potential Predictors

Presence of wound infection was considered as the main study outcome. Potential predictors included were patient's age in years, patient's body mass index, presence of other disease/s, diabetes, ASA score, surgical discipline, grade of operator, type of surgical technique, wound classification, duration of operation in hours, surgical drain and pre and post operative stay in days.

Statistical Analysis

Percentages and means were used to describe the variables. Analysis aimed to develop a multivariate model to allow prediction of outcome in the presence of potential predictors or covariates. Crude logistic regression analyses were performed as initial steps of qualifying covariates to be included in multivariate logistic regression analyses. Covariates with p-values <= 0.25 were included to develop an initial reduced model.[10] Multicolinearity among the covariates was assessed using variance inflation factors. Variables that tested insignificant (with p-values > 0.05) were then eliminated from this model and interactions were tested. Each variable was sequentially removed at a time and its significance was tested. Likelihood ratio tests were used to compare models and Hosmer and Lemeshow test was used to assess goodness of fit of the final model.[10] All statistical tests were conducted by using STATA version 12.[11]

Table I. Patients and procedures characteristics

Background characteristics	(n)	Percentage
Gender		
Male	249	18.0
Female	1138	82.0
Age (years)		
<30	412	29.7
30 to <40	510	36.8
40 to <50	201	14.5
>=50	264	19.0
Body mass index (Kg/m^2)		
<20	134	9.6
20 to <25	570	41.1
25 to <30	417	30.1
>=30	266	19.2
Co-morbidity		
Yes	173	12.5
No	1214	87.5
Diabetes		
Yes	62	4.5
No	1325	95.5

ASA score		
1	1100	79.3
2	208	15.0
3+	79	5.7
Surgical discipline		
Obstetrics and Gynecoloy	725	52.3
General surgery	540	38.9
Urology	122	8.8
Operator		
Surgeon	563	40.6
Others (registrars, medical officer & house officers)	804	58.0
Missing	20	1.4
Skin preparation		
Isopropyl alcohol + chlorohexidine	1173	84.6
Isopropyl alcohol + detergent	129	9.3
Isopropyl alcohol + Iodine	73	5.3
Missing	12	0.8
Preoperative antibiotic		
Yes	1359	98
No	28	2
Surgical technique		
Classic	1367	98.6
Laparoscopic	20	1.4
Wound classification		
Clean	426	30.7
Clean contaminated	961	69.3
Duration of operation/ hour		
< 1	841	60.6
>= 1	541	39.0
Missing	5	0.4
Surgical drain		
Yes	405	29.2
No	980	70.7
Missing	2	0.1
Pre operative time		
0-1 day	1085	78.2
> 1 day	302	21.8
Post operative time		
0-1 day	139	10.0
2 days	516	37.2
3 days	360	26.0
4+ days	372	26.8
Total	**1387**	**100**

Results

Patients' characteristics

Overall 3656 patients were operated on; of them 1769 (48.4%) were recruited according to the defined criteria. The patients completed the follow up period were 1387 (78.4%) with a mean age of 35 ± 14 years. The patients lost for follow up were 368 (20.8%) and 14 (0.8%) died.

Females accounted for 82% of the patients that completed the follow up period. Healthy subjects (79.3%) were the majority and obese patients were 19.2%. Table I shows the distribution of patients by background characteristics.

Surgical procedures

A total of 725 (52.3%) patients had their procedures done in the Obstetrics and Gynaecology Department, 540 (38.9%) and 122 (8.8%) in General Surgery and Urology Departments respectively amounting to a total of 1426 performed procedures. The classic surgical technique was used in 98.6% of the studied procedures. More than two third of the operations were classified as clean –contaminated. Duration of operation for nearly 60% of the patients was <1 hour. Table I shows the characteristics of the performed surgical procedures and Table II presents the distribution of the performed surgical procedures.

Hospital stay

The median duration of hospital stay was 4 days (mean 4 ± 0.08 days). The median preoperative hospital stay was one day (mean 1.8 ± 2.7 days); while the median postoperative stay was 3 days (mean 3.6 ± 3.5 days).

Rate of wound infection

Out of the total patients included in this study, the wound healed satisfactory for 1262 (91.0%) patients and 125 (9%) had a wound infection. The signs of wound infections were detected during hospital

Table II. The distribution of the performed clean and clean- contaminated surgical procedures

Clean procedure	Frequency (%)	Clean contaminated procedure	Frequency (%)
Neck surgery	157 (11.0%)	Cesarean section	578 (40.5%)
Mastectomy	97 (6.8%)	Open cholecystectomy	98 (6.9%)
Hernia repair	75 (5.3%)	Abdominal hysterectomy	65 (4.5%)
Varicocelectomy	19 (1.3%)	Myomectomy	47 (3.3%)
Orchidectomy	17 (1.2%)	Laprotomy	46 (3.2%)
Hydrocelectomy	16 (1.1%)	Prostatectomy	32 (2.2%)
Thoracic surgery	9 (0.6%)	Laparoscopic cholecystectomy	20 (1.4%)
Vascular surgery	8 (0.6%)	Tubes ligation	18 (1.2%)
Orchidopexy	5 (0.4%)	Vesicolithotomy	14 (1.0%)
Others	24 (1.7%)	Nephrectomy	14 (1.0%)
		Ovariancystectomy	13 (0.9%)
		Appendectomy	10 (0.7%)
		Pyelolithotomy	8 (0.6%)
		Gastric surgery	8 (0.6%)
		Splenectomy	7 (0.5%)
		Ureterolithotomy	7 (0.5%)
		Colon surgery	5 (0.4%)
		Small bowel surgery	4 (0.3%)
		Oesophageal surgery	3 (0.2%)
		Others	3 (0.2%)
Total	**427 (30%)**	**Total**	**1000 (70%)**

stay for 15 (12%) patients. Wound infection was recognized during the post-discharge period for 110 (88%) patients; for 63 (57.3%) their infections were confirmed by the surgical units that performed the procedures when they returned back to the hospital and 47 (42.7%) reported the signs through telephone contacts. The majority of the infected wounds 120 (96%) were superficial and only 5 (4%) were classified as deep incisional.

The rate of wound infection was 18.8%, 17.8% and 13.4% among patients operated on for the removal of the prostate gland, gallbladder, and benign or malignant breast tumours respectively. Table III shows the rate of wound infection by category of surgical procedure.

Wound infection risk factors

Univariate logistic analysis revealed that five variables were significantly associated with the prevalence of wound infection; namely patient's body mass index (P=0.041), co-morbidity (P=0.006), presence of diabetes (P=0.010), ASA score (P=0.000) and laparoscopic technique (P=0.007) (Table IV). Multivariate logistic analysis showed that ASA score and laparoscopic technique were the only significant predictors of wound infection after controlling for all other potential confounders (Table IV). Patients with ASA score 2 had almost twice the odds of developing wound infection compared with patients who had ASA score 1 [adjusted OR 1.9 (1.2-3.0), P =0.006]. This odds almost doubled for patients with ASA ≥3 [adjusted OR 3.6 (2.0-6.7); P <0.001]. Patients who had operations using laparoscopic technique had almost 6 fold odds of developing wound infection compared to those who had operations using the classic technique [adjusted OR 5.5 (2-14.8); P=0.001].

Discussion

Despite improvements in prevention, SSIs remain a significant clinical problem as they are associated with substantial mortality and morbidly and impose severe demand on healthcare resources.[12] More than 3% of the surgical patients may probably be affected by surgical site infections.[4]

Table III. Percentages of patients with wound infection by category of surgical procedure

Category of surgical procedure	No of infected patients	Percentage	Total	Confidence interval
Oesophageal surgery	1	33.3	3	-
Prostatectomy	6	18.8	32	(0.07 - 0 .36)
Hydrocelectomy	3	18.8	16	-
Cholecystectomy	21	17.8	118	(0.11 - 0 .26)
Vesicolithotomy	2	14.3	14	-
Mastectomy	13	13.4	97	(0.07 - 0 .22)
Gastric surgery	1	12.5	8	-
Vascular surgery	1	12.5	8	-
Pyelolithotomy	1	12.5	8	-
Cesarean section	48	8.3	578	(0.06 - 0 .11)
Hernia repair	6	8.0	75	(0.03 - 0.17)
Abdominal hysterectomy	6	9.2	65	(0.03 - 0.19)
Nephrectomy	1	7.1	14	
Laprotomy	3	6.5	46	(0.01 - 0 .18)
Neck surgery	7	4.5	157	(0.02 - 0.09)
Myomectomy	1	2.1	47	-
Others	4	14.8	27	-
Total	**125**			

Table IV. Risk factors for wound infection

Covariates	% with wound infection	n	Univariable analysis Crude OR (95% CI)	p-value	Multivariable analysis Adjusted OR (95% CI)	p-value
Gender				0.914		
Male	8.8	249	1.0			
Female	9.1	1138	1.0 (0.6-1.7)			
Age (years)				0.129		
<30	8.0	412	1.0			
30 to <40	8.4	510	1.1 (0.7-1.7)			
40 to <50	7.5	201	0.9 (0.5-1.7)			
>=50	12.9	264	1.7 (1.0-2.8)			
Body mass index (kg/ m2)				0.041		
<20	9.7	134	1.0		1.0	
20 to <25	7.4	570	0.7 (0.4-1.4)		0.8 (0.4-1.6)	0.575
25 to <30	8.2	417	0.8 (0.4-1.6)		0.9 (0.5-1.9)	0.861
>=30	13.5	266	1.5 (0.7-2.9)		1.8 (0.9-3.6)	0.109
Co-morbidity				0.006		
Yes	15.0	173	1.0			
No	8.2	1214	0.5 (0.3-0.8)			
Diabetes				0.010		
Yes	19.4	62	1.0			
No	8.5	1325	0.4 (0.2-0.8)			
ASA score				<0.001		
1	7.4	1100	1.0		1.0	
2	13.5	208	2.0 (1.2-3.1)		1.9 (1.2-3.0)	0.006
3+	20.0	79	3.2 (1.8-5.8)		3.6 (2.0-6.7)	<0.001
Surgical discipline				0.142		
Obstetrics and Gynecoloy	7.7	725	1.0			
General surgery	10.9	540	1.5 (1.0-2.2)			
Urology	8.2	122	1.1 (0.5-2.2)			
Operator				0.369		
Surgeon	8.2	563	1.0			
Others(registrars, medical officer & house officers)	9.6	804	1.2 (0.8-1.7)			
Missing		20				
Surgical technique				0.007		
Classic	8.7	1367	1.0		1.0	
Laparoscopic	30.0	20	4.5 (1.7-11.9)		5.5 (2.0-14.8)	0.001
Wound Classification				0.387		
Clean	8.0	426	1.0			
Clean contaminated	9.5	961	1.2 (0.8-1.8)			
Duration of operation/hour				0.333		
< 1	8.4	841	1.0			
>= 1	10.0	541	1.2 (0.8-1.7)			
Missing		5				

Surgical drain done				0.481
Yes	9.9	405	1.0	
No	8.7	980	0.9 (0.6-1.3)	
Missing		2		
Pre- operative time				0.532
0-1 day	8.8	1085	1.0	
> 1 day	9.9	302	1.1 (0.7-1.8)	
Post- operative time				0.117
0-1 day	5.0	139	1.0	
2 days	7.9	516	1.6 (0.7-3.7)	
3 days	10.8	360	2.3 (1.0-5.3)	
4+ days	10.2	372	2.1 (0.9-4.9)	
Total		**1387**		

The analysis of the demographic variables of the patients included in this study revealed that; the number of females operated on was the majority. This may be partially explained by the fact that the number of patients recruited from the Obstetrics and Gynecology Department were more than those recruited from the other two departments. Brown *et al.*[13] in their study also found a high percentage of females (61%). Out of the total number of patients included in this research; 19% were ≥50 years old. In many countries; populations are becoming older; and increasing number of elderly patients are being referred for surgery. The occurrence of chronic diseases among those patients decreases their immunity and contributes to the increased risk of SSI; postoperative morbidity, and mortality.[14] The results revealed that 19.2% of the patients operated on were obese. Several studies of diverse populations of patients showed that the risk of postoperative infection among obese patients is clearly higher, in particular, their risk of SSI.[15]

The study determined that the overall rate of wound infection was 9%. This is in agreement with the rate observed by Lilani *et al.* [16] as they reported a rate of 8.95% in such type of surgical interventions. However, the rate of infection in the clean wounds was high (8.0%) in this study when compared to the rate of (3.03%) reported in the above mentioned study.[16] Postoperative infections after clean procedures are most probably caused by bacteria that are part of the skin flora. Exogenous sources may also be a factor, such as infected or colonized healthcare workers, the operating room environment or instruments.[17] The increased rate of infection among patients operated on for clean operations may be attributed to improper adherence to infection control measures for disinfection of the skin of both the patient and healthcare workers, and sterilization of surgical instruments.

The rate of wound infection after clean–contaminated operations was 9.5%. It was low when compared with the rate of infection of 17.8% and 19.4% that was respectively reported by Eriksen *et al.*[18]and Mosood *et al.*[19] In such type of clean- contaminated surgeries the expected range was between 4-10%.[6]

Wound infection rate among patients operated on for the removal of the prostate gland was 18.8 %; Brown *et al.*[20] found, in their multivariate analysis, that prostate surgery was the strongest predictor of infection. The observed rate of postoperative wound infection after cholecystectomy procedures was 17.8%. Soleto *et al.*[21] in their study observed a rate of 15% among patients operated on for removal of the gallbladder. Surprisingly the rate of wound infection among patients operated on for laparoscopic removal of the gallbladder was 30%. The increased rate among those patients may be attributed to the failure in the sterilization process of the laparoscope. Also as this surgical technique was not commonly used in this hospital; the improper tissue handling during the procedure may be a contributory factor in increasing the risk of infection. In contrast to our finding Petrosillo *et al.*[22] observed no significant difference in SSI rate between patients operated on for removal of the gallbladder by both techniques.

The analysis of risk factors showed that infection rate increased in older patients with ages ≥50 years when compared with other patients' subgroups, but this results not statistically significant; Neumayer *et al.*[23] found an association between the prevalence of SSI and patient's age >40 years old. Univariate analysis of risk factors in this study showed that; the rate of wound infection increased in diabetics and obese patients with body mass index ≥ 30 kg/ m^2. Di Leo *et al.*[24] found by multivariable analysis both the above mentioned factors were independently associated with a higher risk of surgical site infection. Multivariable logistic regression analysis showed that the patient physical status as measured by ASA score was significantly associated with the incidence of wound infection. Likewise Narong *et al.*[25] identified among other factors poor physical status according to ASA classification to be associated with SSI.

The increased rate of infection observed in this study at the departmental level or per surgical category may be attributed to the high number of surgical interventions performed each day which may affect appropriate patient assessment and preoperative preparation. This was beside the limited resources dedicated for the implementation of proper infection control measures.

Despite the fact that there was an infection control committee in the hospital during the study time, it was observed that there was no system in place to collect data about hospital acquired infections. This may contribute to the increased rate of infection in this study. Surveillance of hospital-acquired infections with feedback to the clinical staff has been shown in previous studies to be associated with reduced rates of wound infections.[26-28]

The majority of wound infections in the current study occurred during the post-discharge period. This may be explained by the fact that the median postoperative stay after the studied procedures was very short (median was 3 days). This result emphasized the importance of post-discharge surveillance in identifying the actual infection rates.

Some patients may fail to identify minor signs of wound infection when interviewed through telephone contact and this can be one of the limitations of this study. Also there was not another method available to follow up the patient when communication with them was lost.

The authors recommend strict adherence to infection control measures, giving infection prevention more attention with allocation of resources, and stressing the importance of the establishment of a network for regular surveillance of nosocomial infections. Strict adherence to the standardized steps involved in the sterilization process of the laparoscope is mandatory.

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