CONCISE COMMUNICATION

Risk Factors for Surgical Site Infection in a Tanzanian District Hospital: A Challenge for the Traditional National Nosocomial Infections Surveillance System Index

Jan Fehr, MD; Christoph Hatz, MD; Isaac Soka; Patience Kibatala, MD; Honorathy Urassa, MSc; Thomas Smith, PhD; Hassan Mshinda, PhD; Reno Frei, MD; Andreas Widmer, MD, MS

The incidence of surgical site infections (SSIs) was 24% in a district hospital in Tanzania. Wound classification was not an independent risk factor for SSI, indicating that risk scores developed in industrialized countries may require adjustments for nonindustrialized countries. The National Nosocomial Infections Surveillance system score required adjustments to reliably predict SSI, probably to account for improper hygiene and the lack of adjustment for the duration of surgery (defined as the 75th percentile of the duration for each type of operative procedure) to reflect local circumstances. Multidrug-resistant pathogens, such as methicillin-resistant *Staphylococcus aureus* and gram-negative pathogens expressing broad-spectrum β-lactamases, have already emerged.

Infect Control Hosp Epidemiol 2006; 27:1401-1404

All over the world, surgical site infections (SSIs) are a potential severe danger to surgical patients.[1-3] Nonindustrialized countries face this problem on a larger scale because of the infrastructural and economic limitations of many hospitals,[4,5,6,7] Prospective studies on the incidence of, the risk factors for, and consequences of SSIs in sub-Saharan Africa are available for tertiary care and teaching hospitals but not for primary and secondary care institutions.[8,9] Therefore, we assessed the incidence, risk factors, causative pathogens, and susceptibility patterns associated with SSI in a secondary care hospital in rural Tanzania.

METHODS

This study was performed in the 82-bed department of general surgery that included gynecology and obstetrics at St. Francis Designated District Hospital, a 371-bed hospital in Ifakara (southern Tanzania) that is the only health facility with a surgical department in a region with more than 550,000 people. A mean of 155 surgical interventions are performed per month in the 2 main operating rooms. Surgical instruments are reprocessed by dry heat at 150°C for 60 minutes, without monitoring. Worn out and heavily used muslins with tiny holes were used as drapes and gowns. Between November 2003 and March 2004, all consecutive adult patients admitted for surgery were enrolled. The study was approved by the ethics committees of the participating insitutions in Tanzania and Switzerland. Written informed consent was obtained for every patient participating in our study.

Data were collected by 3 study nurses 24 hours per day and 7 days per week. They recorded patients' characteristics (Table 1), National Nosocomial Infections Surveillance system (NNIS) index variables, and laboratory results.[2] All infections were identified and documented by one of the investigators (J.F.). Patients were assessed daily during hospitalization and for the last time 30 days after surgery. They received a free diagnostic workup and were reimbursed for travel expenses associated with the follow-up visit. In case of a suspected SSI, a digital picture of the infection site was taken, and swab specimens from the wound were incubated overnight. All swab specimens were analyzed by Gram staining and culture on agar (ChroMagar Orientation and ChroMagar *S. aureus* media) in the local laboratory. Colonies from cultures were transferred in transport medium and analyzed monthly at the Microbiology Laboratory, University Hospital Basel (Basel, Switzerland) according to standard methods. All pathogens were stored at −70°C, in accordance with CLSI recommendations.[10]

The risk of SSI in relation to patient characteristics was assessed using univariate and multivariate statistical analyses.

RESULTS

Six hundred thirteen (99.2%) of 618 eligible patients were included in the study. Five patients were not enrolled either because they refused to participate or because no major procedure was done (ie, the patient left the clinic the same day the intervention was done). One hundred forty-four (23.5%) of the 613 patients developed an SSI. According to the Centers for Disease Control and Prevention definitions, 55 (38.2%) of the patients had a superficial SSI, 67 (46.5%) had a deep SSI, and 22 (15.3%) had an organ/space SSI. Thirteen patients (2.1%) died, and 2 of these deaths were directly attributable to SSI. For 30 patients (21%), the SSI was identified after discharge from the hospital; 9 of these 30 were readmitted because of SSIs.

The median duration of hospital stay was 5 days (range, 1-70 days), and the median duration of follow-up was 28 days. Two hundred eighty-two (46%) of the 613 patients failed to return for the follow-up visit, mainly because they had to travel for up to 1 day to return to the hospital. The median time for SSI detection was 6 days after surgery. Most patients were young (mean age [±SD], 32 ± 16 years), female (83%), and hospitalized for obstetrical or gynecological problems (eg, emergency cesarean section) (Table 1).

In the univariate analysis, risk factors for SSI were an American Society of Anesthesiologists (ASA) physical status clas-

Downloaded from https://www.cambridge.org/core. University of Basel Library, on 30 May 2017 at 20:26:33, subject to the Cambridge Core terms of use, available at https://www.cambridge.org/core/terms. https://doi.org/10.1086/509855

TABLE 1. Demographic and Clinical Characteristics of Patients in the Study

Variable	All patients (n = 613)	Patients with SSI (n = 144)	Risk ratio (95% CI)	P[a]
Female sex	509 (83)	113 (22)	0.7 (0.5-1.0)	.1
Age, mean y ± SD	32.0 ± 13.6	32.6 ± 13.8		
Type of diagnosis at admission				
Obstetric or gynecological	462 (75)	106 (23)	Reference	0.4
Visceral (including hernia)	91 (15)	22 (24)	1.1 (0.7-1.6)	
Orthopedic	28 (5)	10 (36)	1.6 (0.9-2.7)	
Urological	18 (3)	5 (28)	1.2 (0.6-2.6)	
Dermatological or angiological	6 (1)	1 (17)	0.7 (0.1-4.4)	
Ear, nose, or throat	8 (1)	0 (0)	0	
Preoperative clinical characteristics				
Body temperature >37.5°C	75 (13)	13 (17)	0.7 (0.4-1.3)	.3
Tachycardia	24 (4)	9 (38)	1.7 (1.0-2.9)	.1
Hypertension	159 (26)	39 (25)	1.1 (0.8-1.4)	.6
Underweight (BMI <18)	61 (11)	11 (18)	0.7 (0.4-1.4)	.9
Obesity (BMI >25)	101 (18)	29 (29)	1.3 (0.9-1.9)	.1
Anemia[b]	176 (77)	44 (25)	0.9 (0.6-1.5)	.7
Hyperglycemia (glucose level >6.4 mmol/L)	72 (15)	21 (29)	1.3 (0.9-2.0)	.2
Presence of *Plasmodium* species	40 (9)	13 (33)	1.4 (0.9, 2.2)	.2
ASA physical status classification				
1	463 (76)	94 (20)	Reference	0.006
2	80 (13)	25 (32)	1.5 (1.1-2.2)	
3	45 (7)	16 (36)	1.8 (1.1-2.7)	
4	22 (4)	9 (41)	2.0 (1.2-3.4)	
5	0 (0)	0 (0)	...	
Type of surgical intervention				
Emergency surgery	354 (61)	86 (24)	1.1 (0.7-1.3)	.7
Cesarean section	362 (59)	87 (24)	Reference	<.01
Hysterectomy	28 (4)	10 (36)	1.5 (0.9-2.5)	
Laparotomy	46 (8)	10 (22)	0.9 (0.5-1.6)	
Hernia repair	43 (7)	4 (9)	0.4 (0.2-1.0)	
Hydrocele repair	24 (4)	11 (46)	1.9 (1.2-3.1)	
Orthopedic	20 (3)	6 (30)	1.3 (0.6-2.5)	
Other	90 (15)	16 (18)	0.7 (0.5-1.2)	
Wound classification				
Clean	123 (20)	21 (17)	Reference	.01
Clean-contaminated	404 (66)	93 (23)	1.4 (0.9, 2.1)	
Dirty	69 (11)	22 (32)	1.9 (1.1-3.1)	
Dirty-infected	17 (3)	8 (47)	2.8 (1.5-5.2)	
Perioperative management				
General anesthesia	208 (34)	58 (28)	1.3 (1.0-1.8)	.06
Intensive care unit	94 (15)	29 (31)	1.4 (1.0-2.0)	.06
Blood transfusion	42 (7)	15 (36)	1.5 (1.0-2.3)	.08
Urinary catheter	475 (79)	118 (25)	1.3 (0.9-2.0)	.14

NOTE. Data are no. (%) of assessed patients, unless otherwise specified. ASA, American Society of Anesthesiologists; BMI, body mass index; CI, confidence interval; SSI, surgical site infection.

[a] P values from the contingency-table χ^2 (single variable) analyses.

[b] Hemoglobin <120 g/L (females) or <140 g/L (males).

sification of 2 or higher, duration of surgery greater than the 75th percentile of the duration for the relevant type of operative procedure, type of intervention, and wound classification of dirty or dirty-infected (Table 1). There was no significant effect found for any patient-related risk factors tested (eg, clinical data, such as body mass index, or laboratory findings, such as anemia or hyperglycemia) (Table 1). Only 2 of these risk factors remained significantly associated with SSI in the multivariate analysis. First, patients with an ASA classification of 2-4 (no score of 5 was ever reported) had a significantly higher risk of SSI ($P < .05$; Table 1). Second, patients with relatively long durations of operation, de-

Downloaded from https://www.cambridge.org/core. University of Basel Library, on 30 May 2017 at 20:26:33, subject to the Cambridge Core terms of use, available at https://www.cambridge.org/core/terms. https://doi.org/10.1086/509855

fined as a duration longer than the 75th percentile of the local value for duration of surgery, had an increased risk of SSI (relative risk, 1.9 [95% confidence interval, 1.4-2.6]; χ^2, 16.2; $P < .01$) (Table 2). However, only 10 operations had durations longer than the 75th percentile of the international value for duration of surgery.[2] Therefore, a meaningful comparison between durations relative to the local 75th percentile and durations relative to the international 75th percentile was not feasible. Adjustment for these 2 variables allowed us to account for the effects of the other risk factors, in particular for the effect of the wound classification score and the type of surgical intervention.

Staphylococcus aureus was isolated from 48 (37%) of the 144 patients with SSI, *Escherichia coli* from 15 (11%), and *Enterococcus* species from 7 (5%). Other clinically relevant bacteria, such as *Klebsiella* species, *Proteus* species, Enterobacteriaceae, *Pseudomonas aeruginosa,* and *Acinetobacter* species were found in 17 patients (12%). Instances in which coagulase-negative staphylococci, *Corynebacterium* species, or *Bacillus* species were detected or in which culture yielded no growth (noted for 14 patients) were grouped together under the category "no clinically significant organism detected"; this category was noted for 47 patients (35%). Surprisingly, we identified 1 strain of methicillin-resistant *S. aureus* in this remote hospital. In addition, 18% of all gram-negative pathogens produced extended-spectrum β-lactamase (ESBL). Three *Enterococcus* isolates were resistant to vancomycin.

DISCUSSION

The incidence of SSI in our hospital in Tanzania was high, compared with the incidence in industrialized countries.[1,2] However, hospitals in nonindustrialized countries indicate similar rates.[11,12] Eriksen et al.[8] reported an SSI rate of 19% at the Kilimanjaro Christian Medical Center, Tanzania, and Kotisso et al.[9] reported an overall rate of 21% in Ethiopia. However, these studies were performed in tertiary care and teaching hospitals. For small hospitals, such data are not available. The proportion of SSIs that were deep or organ/space infections was 62% in our study, which is higher than proportions reported in the literature.[13] In a study from Bolivia by Soleto et al.,[14] it was found that 93% of SSIs were superficial, 4% were deep, and 2% were organ/space infections. Eriksen et al.[8] reported that in their facility in Tanzania, 69% were deep SSIs, 21% were superficial SSIs, and 10% were organ/space SSIs.

Only an ASA classification greater than 1 and duration of the operation longer than the local 75th percentile for duration of surgery turned out to be significant risk factors for SSI. Interestingly, wound classification was not an independent predictor of SSI in the multivariate logistic regression analysis. Values for the duration of surgery were very short, compared with durations in industrialized countries; only 10 operations had a duration longer than the 75th percentile of the duration of surgery used in the NNIS index. A duration of surgery longer than the local 75th percentile value was a strong risk factor for SSI. Campos et al.[15] also recommended that this parameter be adjusted on the basis of data from the local hospital before it is used to predict SSIs. We assume that the short operation time is a factor associated with protection against SSIs.

Several reasons may explain the high SSI rate and the fact that wound classification was not an independent predictor for SSI. First, surgical instruments were supposed to be processed by dry heat at 150°C for 60 minutes, as there was no

TABLE 2. Association Between Duration of Surgery and Risk of Surgical Site Infection (SSI), According to Operative Procedure

	Duration of surgery, min		No. (%) of patients, by relative duration of surgery			
			<75th percentile		>75th percentile	
Procedure	Median	75th percentile	All	With SSI	All	With SSI
Cesarean section	30	35	266	56 (21)	88	29 (33)
Hysterectomy	32	42	22	7 (32)	7	3 (43)
Laparotomy	30	40	36	5 (14)	9	4 (44)
Hernia repair[a]	19	29	28	3 (11)	9	0
Hydrocele repair[a]	19	30	14	8 (57)	4	2 (50)
Orthopedic intervention	30	40	16	4 (25)	3	2 (67)
All	28	35	459	95 (21)	137	44 (32)

NOTE. All values for the 75th percentile of the distribution of times for the intervention are for the local area of the study. For patients with a duration of surgery greater than the 75th percentile value, the relative risk of SSI was 1.6 (95% confidence interval, 1.2-2.0; χ^2, 9.7; $P = .002$).

[a] Excluding 6 patients who underwent both hernia and hydrocele operations, of whom only 1 had an SSI.

Downloaded from https://www.cambridge.org/core. University of Basel Library, on 30 May 2017 at 20:26:33, subject to the Cambridge Core terms of use, available at https://www.cambridge.org/core/terms. https://doi.org/10.1086/509855

working autoclave at the time of our investigation. However, the thermometer and timer were broken. Hence, there were no sterile instruments, by the standards of industrialized countries, and, consequently, theoretically none of the wounds could have been classified as clean. Pathogens may have been introduced by contaminated instruments into deeper layers during surgical intervention. This may explain the shift from superficial to deep and organ/space SSIs. Holes in overused and improperly reprocessed surgical drapes may also have increased the risk of intraoperative contamination. Second, a high number of surgical interventions (up to 30) were conducted each day, but only 7 instrument sets were available. Appropriate reprocessing was jeopardized because there was not enough time for each cleaning step. Third, a high rate of patient turnover interferes with appropriate assessment and preparation of patients. Up to 25 operations (minor interventions included) were performed by a single surgeon each day of duty.

S. aureus was the most frequently isolated pathogen, as has been reported in other studies from Tanzania.[9,16,17] Importantly, we found multidrug resistance among gram-negative pathogens that produced ESBL, and we found enterococci that were resistant to vancomycin. Enterobacteriaceae that produce ESBL are reported with varying prevalence from all over the world.[18] The genetic diversity and complexity of *Klebsiella pneumoniae* strains have been described in South Africa and Kenya.[19,20] To the best of our knowledge, this is the first report from rural Tanzania of an incidence as high as 18% for ESBL-producing pathogens involved in SSI.

ACKNOWLEDGMENTS

We thank Marcel Tanner, Manuel Battegay, Kathrin Blatter, Sr. Celina, Marc Dangel, Sarina Dürst, Mariette Fankhauser, Julia Ferie, Hajo Grundmann, Judith Heckendorn, Nadja Heuer, Zonya Jeffrey, Bettina Maeschli, John Malugu, Danica Nogarth, Vicky Parker, Tarsis Pius, and all the other people involved in this study, including patients, physicians, the nursing team, and laboratory staff.

This study was financed by the Swiss Academy of Medical Science and the Swiss Tropical Institute.

From the Department of Medicine and Diagnostics, Swiss Tropical Institute (J.F., C.H., T.S.), and the Division of Hospital Epidemiology (J.F., A.W.) and the Bacteriology Laboratory (R.F.), University Hospital Basel, Basel, Switzerland; and the Department of Surgery, St. Francis Designated District Hospital (I.S., P.K.), and the Ifakara Health Research and Development Center (H.U.), Ifakara, Tanzania.

Address reprint requests to Andreas F. Widmer, MD, MS, Division of Infectious Diseases and Hospital Epidemiology, University Hospital Basel, Petersgraben 4, CH-4031 Basel, Switzerland (awidmer@uhbs.ch).

Presented in part: 44th Annual Interscience Conference on Antimicrobial Agents and Chemotherapy, October 2004, Washington, DC.

Received August 13, 2005; accepted December 17, 2005; electronically published November 22, 2006.

© 2006 by The Society for Healthcare Epidemiology of America. All rights reserved. 0899-823X/2006/2712-0019$15.00.

REFERENCES

1. National Nosocomial Infections Surveillance (NNIS) System Report, data summary from January 1992 through June 2004, issued October 2004. *Am J Infect Control* 2004; 32:470-485.
2. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Hospital Infection Control Practices Advisory Committee. *Infect Control Hosp Epidemiol* 1999; 20: 250-278.
3. Kirkland KB, Briggs JP, Trivette SL, Wilkinson WE, Sexton DJ. The impact of surgical-site infections in the 1990s: attributable mortality, excess length of hospitalization, and extra costs. *Infect Control Hosp Epidemiol* 1999; 20:725-730.
4. Habte-Gabr E, Gedebou M, Kronvall G. Hospital-acquired infections among surgical patients in Tikur Anbessa Hospital, Addis Ababa, Ethiopia. *Am J Infect Control* 1988; 16:7-13.
5. Raza MW, Kazi BM, Mustafa M, Gould FK. Developing countries have their own characteristic problems with infection control. *J Hosp Infect* 2004; 57:294-299.
6. Nyamogoba H, Obala AA. Nosocomial infections in developing countries: cost effective control and prevention. *East Afr Med J* 2002; 79:435-441.
7. Meers PD. Infection control in developing countries. *J Hosp Infect* 1988; 11(Suppl A):406-410.
8. Eriksen HM, Chugulu S, Kondo S, Lingaas E. Surgical-site infections at Kilimanjaro Christian Medical Center. *J Hosp Infect* 2003; 55:14-20.
9. Kotisso B, Aseffa A. Surgical wound infection in a teaching hospital in Ethiopia. *East Afr Med J* 1998; 75:402-405.
10. Zapantis A, Lacy MK, Horvat RT, et al. Nationwide antibiogram analysis using NCCLS M39-A guidelines. *J Clin Microbiol* 2005; 43:2629-2634.
11. Loefler IJ. Surgical wound infection in the Third World: the African experience. *J Med Microbiol* 1998; 47:471-473.
12. Prabhakar P, Raje D, Castle D, et al. Nosocomial surgical infections: incidence and cost in a developing country. *Am J Infect Control* 1983; 11:51-56.
13. NINSS reports on surgical site infection and hospital acquired bacteraemia. *Commun Dis Rep CDR Wkly* 2000; 10:213-216.
14. Soleto L, Pirard M, Boelaert M, et al. Incidence of surgical-site infections and the validity of the National Nosocomial Infections Surveillance System risk index in a general surgical ward in Santa Cruz, Bolivia. *Infect Control Hosp Epidemiol* 2003; 24:26-30.
15. Campos ML, Cipriano ZM, Freitas PF. Suitability of the NNIS index for estimating surgical-site infection risk at a small university hospital in Brazil. *Infect Control Hosp Epidemiol* 2001; 22:268-272.
16. Blomberg B, Mwakagile DS, Urassa WK, et al. Surveillance of antimicrobial resistance at a tertiary hospital in Tanzania. *BMC Public Health* 2004; 4:45.
17. Urassa WK, Haule EA, Kagoma C, Langeland N. Antimicrobial susceptibility of *Staphylococcus aureus* strains at Muhimbili Medical Centre, Tanzania. *East Afr Med J* 1999; 76:693-695.
18. Turner PJ. Extended-spectrum beta-lactamases. *Clin Infect Dis* 2005; 41(Suppl 4):S273-S275.
19. Kariuki S, Corkill JE, Revathi G, Musoke R, Hart CA. Molecular characterization of a novel plasmid-encoded cefotaximase (CTX-M-12) found in clinical *Klebsiella pneumoniae* isolates from Kenya. *Antimicrob Agents Chemother* 2001; 45:2141-2143.
20. Essack SY, Hall LM, Livermore DM. *Klebsiella pneumoniae* isolate from South Africa with multiple TEM, SHV and AmpC beta-lactamases. *Int J Antimicrob Agents* 2004; 23:398-400.

Downloaded from https://www.cambridge.org/core. University of Basel Library, on 30 May 2017 at 20:26:33, subject to the Cambridge Core terms of use, available at https://www.cambridge.org/core/terms. https://doi.org/10.1086/509855