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

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ABSTRACT

OBJECTIVES: To estimate the frequency of and risk factors for surgical-site infections (SSIs) in Bolivia, and to study the performance of the National Nosocomial Infections Surveillance (NNIS) System risk index in a developing country.

DESIGN: A prospective study with patient follow-up until the 30th postoperative day.

SETTING: A general surgical ward of a public hospital in Santa Cruz, Bolivia.

PATIENTS: Patients admitted to the ward between July 1998 and June 1999 on whom surgical procedures were performed.

RESULTS: Follow-up was complete for 91.5% of 376 surgical procedures. The overall SSI rate was 12%. Thirty-four (75.6%) of the 45 SSIs were culture positive. A logistic regression model retained an American Society of Anesthesiologists score of more than 1 (odds ratio [OR], 1.87), a not-clean wound class (OR, 2.28), a procedure duration of more than 1 hour (OR, 1.81), and drain (OR, 1.98) as independent risk factors for SSI. There was no significant association between the NNIS System risk index and SSI rates. However, a "local" risk index constructed with the above cutoff points showed a linear trend with SSI ($P < .001$) and a relative risk of 3.18 for risk class 3 versus a class of less than 3.

CONCLUSIONS: SSIs cause considerable morbidity in Santa Cruz. Appropriate nosocomial infection surveillance and control should be introduced. The NNIS System risk index did not discriminate between patients at low and high risk for SSI in this hospital setting, but a risk score based on local cutoff points performed substantially better (*Infect Control Hosp Epidemiol* 2003;24:26-30).

Surgical-site infections (SSIs) cause an important share of hospital-acquired infections among surgical patients.[1] Patients who develop SSIs have longer and more expensive hospitalizations and are twice as likely to die.[2] Because individual feedback to surgeons on SSI rates was shown to reduce incidence, active surveillance of SSI has been advocated.[3] In 1992, a consensus was reached on the surveillance methodology for SSI in the United States.[4] To allow for valid comparisons of SSI between surgeons and institutions and across different time periods, patient populations have to be stratified by risk categories. Because the traditional system of wound classification in use since 1964 did not take into account intrinsic patient risk factors, the consensus paper recommended the use of composite risk indexes.

On the basis of data from the Study on the Efficacy of Nosocomial Infection Control (SENIC), Haley et al. showed that the SENIC index predicts SSI rates twice as well as the traditional wound classification system.[5] Later, the National Nosocomial Infections Surveillance (NNIS) System risk index was adopted, which takes into account the specific operative procedure.[6] The NNIS System risk index correlates well with SSI rates, but its adequacy to stratify risk within specific procedures has been questioned.[7,8] Nevertheless, the NNIS System risk index performed consistently well in Europe[9,10] and pleas for converging approaches in surveillance methodology have been formulated.[11]

In Latin America, hospital infection epidemiology and control has received wider attention during the past 10 years.[12] Brazil[13,14] and Mexico[15,16] have set up, albeit with difficulty, effective nosocomial infection control programs. However, data on SSI are scarce or absent for most countries in Latin America, including Bolivia. In Santa Cruz, a growing metropolis in Bolivia's lowlands, awareness of the burden of nosocomial infection increased during the mid 1990s and control measures were introduced in public hospitals. Nevertheless, these well-meant efforts remained fragmented and the frequency of nosocomial infection in general and of SSI in particular was never assessed.

This study aimed to document the incidence rate of and risk factors for SSI in a general surgical ward of the main public hospital in Santa Cruz. We also assessed the performance of the internationally recommended NNIS System risk index in this developing country.

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METHODS

Study Population

The study was performed in one general surgical ward of a 220-bed public hospital in Santa Cruz de la Sierra, a city with 1 million inhabitants in the tropical region of Bolivia. In addition to three wards for adult general surgery, this hospital had specialized neurosurgery, trauma, and urology wards. The general ward where this study was performed had 26 beds and was selected because the surgeon in charge (RP) had a keen interest in setting up a system to control SSI. No active nosocomial infection surveillance system was in place at the start of the study. All surgical interventions performed between July 1, 1998, and June 30, 1999, were included, with the exception of skin grafts for burns. Reoperations for complications within 30 days after discharge were excluded from the sample, but other procedures for the same patient were considered to be independent and were included.

Data Collection

Resident physicians were trained in the use of the study protocol and made all observations under the supervision of two of the authors (RP and RV). Clinical data and potential risk factors for SSI were registered for each patient. The surgical site was inspected daily during the hospital stay and on the 7th and the 30th postoperative days. If patients failed to attend their postdischarge appointments, a resident physician made a home visit. When there was clinical suspicion of wound infection (defined according to Centers for Disease Control and Prevention [CDC] criteria[17]), a sample was taken for culture and transported to the bacteriology laboratory of the Centro Nacional de Enfermedades Tropicales (CENETROP) in Stuart transport medium (Difco, Detroit, MI). Culture (Difco) and antibiogram (BBL, Cockeysville, MD) were performed following routine procedures. Antimicrobial sensitivity tests were performed using the Kirby–Bauer method.[18]

Case Definitions

CDC NNIS System criteria were used to define SSIs and classify the cases as superficial incisional, deep incisional, or organ–space SSI.[17] Wound class was defined by the surgeons according to CDC criteria as clean, clean contaminated, contaminated, or dirty infected.[19] The American Society of Anesthesiologists (ASA) score[20] was recorded as 1 (healthy), 2 (mild systemic disease), 3 (severe systemic disease), 4 (severe life-threatening systemic disease), or 5 (moribund). For each patient, the NNIS System risk index was computed as an ASA score of more than 2, a wound class of contaminated or dirty–infected, and a duration of the procedure of more than T hours (T = 75th percentile), with each criterion adding 1 point to the index.[6]

Data Analysis

Point estimates and 95% confidence intervals were computed for the cumulative incidence rate of SSI during 30 days and for the relative risk associated with potential risk factors. Potential risk factors and confounders, identified on the basis of a priori knowledge and in bivariate analysis, were considered for inclusion in a logistic regression model. The modeling strategy recommended by Kleinbaum et al.[21] was adopted to select the factors to be withheld in the final model. Statistical analyses were performed using Epi-Info (version 6.04; CDC, Atlanta, GA)[22] and EGRET for Windows (version 2000/NT/98/95; Cytel Software Corp., Cambridge, MA) software. The independent risk factors retained in the optimal model were used to construct a modified SSI risk index score, the Local Nosocomial Infection Surveillance (LNIS) index, with levels (0, 1, 2, and 3). An ASA score of more than 1, a wound class of not clean, and a duration of procedure of more than 1 hour each added 1 point to the LNIS index score.

RESULTS

Between July 1, 1998, and June 30, 1999, all 376 eligible surgical procedures in 372 patients were included in the study. Three hundred seventy-four (99.5%) of the surgical wounds could be assessed at the seventh day after the procedure and a complete 30-day follow-up was achieved for 344 (91.5%) of the procedures. Reasons for loss to follow-up despite home visits were rural residence (19 patients), incomplete address (11 patients), death not related to the surgical procedure (1 patient), and incarceration (1 patient).

The median duration of hospitalization was 7 days (interquartile range, 5 to 11 days), patients were female in 237 of the 376 procedures (63%), and the median age was 38 years (interquartile range, 26.0 to 51.5). Seventy-two percent (272 of 376) of the procedures were abdominal. Drains were used in 82 (21.8%) of the procedures and implants (mainly for herniorrhaphy) in 31 (8.2%).

No antibiotic prophylaxis was used for 51.6% of the patients. The hospital's standard regimen (based on 3 doses of first-generation cephalosporins with dose 1 at the start of the procedure, dose 2 after 6 hours, and dose 3 after 12 hours) was used in 32.2% and alternative regimens were used in 16.2% of the procedures. Prophylaxis was administered in 42.2% (43 of 102) of the procedures classified as clean.

The overall cumulative incidence rate of SSI was 12% (95% confidence interval [CI_{95}], 8.9% to 15.7%). The rate was 6.9% for clean (n = 102), 13.7% for clean-contaminated (n = 248), 15.8% for contaminated (n = 19), and 14.3% for dirty-infected wounds (n = 7). Case mix and procedure-specific SSI rates are detailed in Table 1.

Forty-two (93.3%) of the 45 SSIs were superficial incisional, 2 were deep incisional, and 1 was organ–space. Thirty-six (80%) of the 45 SSIs were detected during the hospital stay of the patient. For patients with an SSI, the mean duration of hospitalization was 16.9 days compared with 8.5 days for those without an SSI ($P < .0001$).

Thirty-four (75.6%) of the 45 clinical infections were culture positive, and 6 (17.6%) of them were polymicrobial infections following gastrointestinal surgery (3 with two species and 3 with three species). The most frequently isolated microbes were *Enterococcus* species (23.3%) and *Staphylococcus aureus* (20.9%). Five of 7 SSIs in the group of

TABLE 1
CASE MIX AND PROCEDURE-SPECIFIC SURGICAL-SITE INFECTION RATES IN A GENERAL SURGICAL WARD IN SANTA CRUZ, BOLIVIA, 1999

Intervention Type	Frequency No. (%)	SSI Rate (%)
Cholecystectomy	193 (51.3)	15.0
Hernia	69 (18.4)	5.8
Appendectomy	59 (15.7)	8.5
Thyroidectomy	14 (3.7)	7.1
Minor surgery	11 (2.9)	18.2
Small bowel surgery	8 (2.1)	12.5
Colon surgery	4 (1.1)	50.0
Other abdominal surgery	9 (2.4)	11.1
Gynecology–obstetrics	5 (1.3)	0
Orthopedic surgery	4 (1.1)	0
All	376 (100)	12.0

SSI = surgical-site infection.

TABLE 2
FREQUENCY DISTRIBUTION OF ISOLATED MICROBES IN 34 CULTURE-POSITIVE SURGICAL-SITE INFECTIONS IN A GENERAL SURGICAL WARD IN SANTA CRUZ, BOLIVIA, 1999

Microbe	No.	%
Enterococcus faecalis	10	23.3
Staphylococcus aureus	9	20.9
Klebsiella pneumoniae	3	7.0
Escherichia coli	4	9.3
Enterobacter aerogenes	3	7.0
Pseudomonas aeruginosa	3	7.0
Citrobacter freundii	3	7.0
Enterobacter cloacae	2	4.7
Providencia stuartii	2	4.7
Proteus mirabilis	1	2.3
Nonfermentative gram-negative bacilli	2	4.7
Salmonella species	1	2.3
Total	43	100

clean surgical procedures were culture positive, of which 4 were due to *S. aureus*. Table 2 lists the overall frequency of the isolated bacteria. Nine (20.9%) of the 43 isolated microbes showed multiple resistance: 3 methicillin-resistant *S. aureus* (MRSA), 4 Enterobacteriaceae resistant to third-generation cephalosporins, and 2 nonfermenting gram-negative bacilli.

Table 3 lists selected potential risk factors related to patient and procedure with their associated SSI rates and relative risks. Only ASA score, duration of the procedure, and presence of a drain were significantly associated with SSI in the bivariate analysis.

Table 4 gives crude and adjusted odds ratios for the risk factors retained in the final logistic model. Only ASA score, wound class, duration of the procedure, and presence of a drain were significant independent risk factors. There were no interactions between risk factors and there was no indication of confounding by age, gender, or other variables.

The SSI rates for the NNIS System risk classes 0 to 3 were 12.0% (37 of 308), 9.1% (5 of 55), 25.0% (3 of 12), and 0% (0 of 1), respectively (Figure). The relative risk for SSI was 1.9 (CI_{95}, 0.71 to 5.60) in the group with an NNIS System risk class of 2 or more versus a class of less than 2. The LNIS risk score, constructed as explained earlier, discriminated better between subgroups at different risk for SSI. The rates were 3.1% (1 of 32), 9.1% (15 of 165), 12.8% (19 of 148), and 32.3% (10 of 31) for classes 0 to 3, respectively (chi-square test for linear trend, 12.01; $P < .001$). The relative risk for an LNIS class of 3 versus a class of lower than 3 was 3.18 (CI_{95}, 1.75 to 5.79).

DISCUSSION

This study is among the few longitudinal studies of SSI in developing countries and it achieved an almost complete 1-month follow-up. The observed crude incidence rate of SSI of 12.0% is comparable to results obtained in prospective studies performed in general surgical wards of a single hospital in the United States (8.6%),[23] Spain (10.5%),[24] and Brazil (16.6%).[25] The proportion of SSIs detected after discharge (20%) was lower than that in Brazil (52.7%)[25] or the United States (53%),[23] but higher than that in Spain (13.5%).[24] So far, no day surgery is being performed in Santa Cruz, and there is no administrative pressure to shorten hospital stay. Given the complete and standardized follow-up, we are confident that underreporting in this study was minimal.

Enterococcus species and *S. aureus* were among the predominant causative agents, as in other studies in a similar setting,[25,26] but the relative frequency of *Escherichia coli* was low. This can be attributed to the relatively low frequency of colon surgery. The isolation of 9 multiresistant microbes among 34 positive cultures is alarming, however. The frequent but sometimes irrational administration of antibiotic prophylaxis in clean surgery, a common problem in Latin America,[27] was without a doubt a contributing factor.

The main risk factors for SSI were similar to the ones identified in other studies, with some exceptions. First, there was no significant relation with age, but the narrow age range of the patients could be an explanation. Second, preoperative length of stay was not predictive of SSI risk. However, its average duration was relatively long, mainly due to organizational problems in the hospital. In Santa Cruz, delays were caused because patients had to buy surgical material prior to the procedure and by strikes, shortage of packs, and unavailability of the operating room. On the other hand, the excess length of stay for patients with SSI was in line with that of earlier reports[2,10] and it reflected the extra morbidity and costs that SSI entails for the patients and hospital.

This study corroborates the association between SSI and ASA score, duration of procedure, and wound

TABLE 3
Selected Patient- and Procedure-Related Potential Risk Factors for Surgical-Site Infection

Risk Factor	SSI No. (%)	Relative Risk (CI_{95})
Patient-related factors		
Age, y		
> 29	34/246 (13.8)	1.63 (0.86 to 3.12)
≤ 29	11/130 (8.5)	—*
Gender		
Male	19/139 (13.7)	1.25 (0.72 to 2.17)
Female	26/237 (11.0)	—
Residence		
Rural	10/81 (12.3)	1.04 (0.54 to 2.0)
Urban	35/294 (11.9)	—
Anesthesia risk score (ASA)		
1	32/308 (10.4)	—
2	13/62 (21.0)	2.0 (1.13 to 3.62)
3	0/6 (0)	0 (0.00 to 7.66)
4	0 (0)	NA
5	0 (0)	NA
Preoperative stay, d		
≥ 7	11/93 (11.8)	1.0 (0.53 to 1.92)
< 7	33/282 (11.7)	—
Obesity		
BMI > 25	29/216 (13.4)	1.33 (0.75 to 2.36)
BMI ≤ 25	16/158 (10.1)	—
Diabetes		
Yes	1/5 (20.0)	1.69 (0.29 to 9.95)
No	44/371 (11.8)	—
Malignancy		
Yes	2/6 (33.3)	2.87 (0.89 to 9.2)
No	43/370 (11.6)	—
Infection at other site		
Yes	3/10 (30.0)	2.6 (0.97 to 7.0)
No	42/366 (11.5)	—
Procedure-related factors		
Emergency surgery		
Yes	10/81 (12.3)	1.04 (0.54 to 2.01)
No	35/295 (11.9)	—
Procedure duration		
> T†	7/50 (14.0)	1.20 (0.57 to 2.54)
≤ T	38/326 (11.7)	—
Procedure duration, h		
> 1	32/212 (15.1)	1.90 (1.03 to 3.51)
≤ 1	13/164 (7.9)	—
Wound class		
Clean	7/102 (6.9)	—
Clean contaminated	34/248 (13.7)	2.00 (0.92 to 4.36)
Contaminated	3/19 (15.8)	2.30 (0.65 to 8.12)
Dirty infected	1/7 (14.3)	2.08 (0.30 to 14.64)
Wound class		
Not clean	38/274 (13.9)	2.02 (0.93 to 4.38)
Clean	7/102 (6.9)	—
Prophylactic antibiotics		
No	22/194 (11.3)	0.90 (0.52 to 1.55)
Yes	23/182 (12.6)	—
Implant		
Yes	3/31 (9.7)	0.79 (0.26 to 2.42)
No	42/345 (12.2)	—
Drain		
Yes	17/82 (20.7)	2.18 (1.26 to 3.78)
No	28/294 (9.5)	—

SSI = surgical-site infection; CI_{95} = 95% confidence interval; BMI = body mass index; ASA = American Society of Anesthesiologists; NA = not applicable.
*Reference category.
†75th percentile of procedure duration as defined by the National Nosocomial Infections Surveillance System.[6]

TABLE 4
Crude Odds Ratios for Potential Risk Factors and Confounders and Adjusted Odds Ratios for Independent Factors Retained in the Logistic Regression Model

Factor	Crude OR (CI_{90})	Adjusted OR (CI_{90})
ASA score > 1	2.04 (1.13 to 3.69)	1.87 (1.02 to 3.44)
Wound class: not clean	2.19 (1.08 to 4.43)	2.28 (1.11 to 4.68)
Procedure duration > 1 h	2.07 (1.17 to 3.65)	1.81 (1.01 to 3.27)
Infection at other site	3.31 (1.03 to 10.62)	—*
Drain	2.49 (1.43 to 4.33)	1.98 (1.11 to 3.52)
Malignancy	3.80 (0.89 to 16.20)	—*
Age > 29 y	1.74 (0.95 to 3.16)	—*
Male	1.28 (0.75 to 2.17)	—*

OR = odds ratio; CI_{90} = 90% confidence interval; ASA = American Society of Anesthesiologists.
*Considered for inclusion but not retained in the final model.

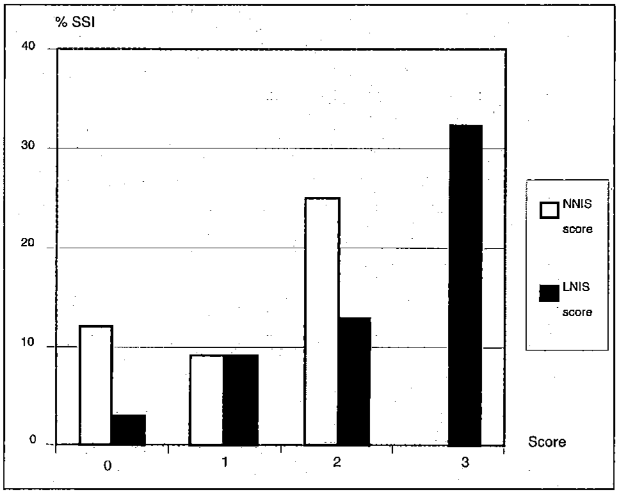

FIGURE. Surgical-site infection (SSI) rate in function of the National Nosocomial Infections Surveillance (NNIS) System and the Local Nosocomial Infection Surveillance (LNIS) risk scores.

class,[6,10,26] but increased risks were observed at lower cutoff points than those used in the NNIS System risk index. The wound class variable discriminated only weakly, probably due to the nature of the most frequently performed procedures. Also, the ASA score, which is indirectly related to both the age of the patient and the specific procedure, contributed less in the context of this general surgical ward in Santa Cruz. Discrepancies in ASA scoring for categories 2 and 3 have been reported,[28] but we do not think this played a major role in our study.

The distribution of the NNIS System risk index in our study population was similar to observations in Spain,[9] but different from the distribution in U.S. hospitals.[2] We did not find an increasing risk for SSI with increasing NNIS System risk category. This is in contrast to a recent retrospective study from Brazil performed—without postdischarge follow-up—in a tertiary-care center that reported a good correlation between the NNIS System risk index and SSI.[29] Our study had low power to detect this association, because few patients belonged to the highest NNIS System risk category. Our prospective results indicate that the classic NNIS System risk index score was not useful for identifying a subgroup of patients at high risk in this general surgical ward of a secondary-level urban hospital in Bolivia. An alternative risk index (LNIS) that used adapted (lower) thresholds for the included risk factors identified them much better. For international comparisons of SSI rates, "universal" methods for risk adjustment are obviously needed. However, the fact that surgical patients in developing countries are generally younger and healthier may make use of such a universal index impractical. If surgeons in such settings want to identify the subgroup of patients on whom SSI prevention efforts could be concentrated within wards, alternative risk indices, such as the one proposed here, may perform better in developing countries and should be studied further.

Meanwhile, a more general nosocomial infection control strategy should be applied to all patients in our study site, because our results demonstrate that there is ample room for improvement. The relatively high rate of staphylococcal infections points to gains that can be expected from reviewing and improving procedures in the operating room.[30] Concurrently, the antibiotic prophylaxis policy should be redefined. It also should be possible to reduce the preoperative length of stay and perhaps the duration of the surgical procedure. Setting up a system for systematic surveillance and control could further contribute to curbing SSI rates over time.[3,16]

Introducing such a program is far from easy in Latin American countries.[13,14,31] Prospects are nevertheless good for Santa Cruz because our study created awareness of the magnitude of the problem of SSI and generated enthusiasm for systematic control efforts among all surgeons in the participating hospital and their colleagues in other institutions. An appropriate nosocomial infection surveillance and control system is currently being designed for all of the urban hospitals in Santa Cruz, and the results of our study have also triggered a response by the national health authorities, who started working toward a nationwide surveillance and control effort.

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