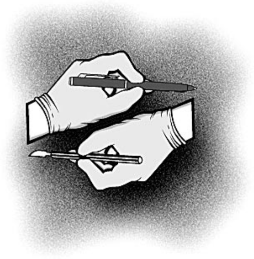

ORIGINAL ARTICLE
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Surgical site infection rates at the Pontiac Health Care Centre, a rural community hospital

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Introduction: The prevalence of surgical site infections (SSIs) at the Pontiac Health Care Centre, a rural hospital, was compared with rates obtained by large multicentre studies. Postoperative nosocomial infection (NI) rates were also calculated.
Methods: A review of all surgical interventions involving an incision, excluding ophthalmological procedures, performed between October 2001 and March 2003 (n = 831) was undertaken. Various clinical parameters were recorded. Infection rates were calculated. Data were analyzed using either the χ^2 or Student's t test.
Results: The overall SSI rate was 5.54%: 3.50% in clean cases (C), 6.77% in clean-contaminated cases (CC), and 14.58% in contaminated or dirty cases (D). The postoperative NI rate was 6.62% (C, 3.68%; CC, 9.90%; D, 16.67%). The mean duration of surgery was significantly higher among patients with SSIs and with NIs than those without infections for CC (133 ± 95 v. 78 ± 60 min, $p < 0.05$, and 129 ± 82 v. 77 ± 60 min, $p < 0.001$ respectively) and D (130 ± 96 v. 82 ± 62 min, $p < 0.001$, and 136 ± 92 v. 80 ± 60 min, $p < 0.001$ respectively). There were significantly higher SSI and NI rates among patients with combined American Society of Anesthesiologists (ASA) scores II and III than those with ASA score I in D (χ^2 = 5.06 and χ^2 = 6.34 respectively). There was also significantly higher SSI and NI rates among patients with combined Comorbidity Scale score 1–6 than those with no comorbid factors in CC (χ^2 = 4.14 and χ^2 = 4.42 repectively) and D (not significant and χ^2 = 4.04 respectively).
Conclusion: SSI rates at the Pontiac Health Care Centre were comparable to multicentre rates. Wound contamination category, type of surgery, duration of surgery, ASA score and Comorbidity Scale score were associated with SSI and NI rates. Studies have shown that examining NI rates decreases these rates by raising awareness; thus, we suggest that rural hospitals implement protocols to survey their postoperative NI rates.

Introduction : On a comparé la prévalence des infections de sites chirurgicaux (ISC) au Centre des soins de santé du Pontiac, un hôpital rural, aux taux établis à la suite de grandes études multicentriques. On a aussi calculé les taux d'infections nosocomiales (IN) postopératoires.
Méthodes : On a entrepris une étude de toutes les interventions chirurgicales comportant une incision, sauf les interventions ophtalmologiques, pratiquées entre octobre 2001 et mars 2003 (n = 831). On a consigné divers paramètres cliniques, calculé les taux d'infection et analysé les données au moyen du test χ^2 ou du test t de Student.
Résultats : Le taux global d'ISC s'est établi à 5,54 % : 3,50 % dans les cas propres (C), 6,77 % dans les cas propres contaminés (CC) et 14,58 % dans les cas souillés (S). Le taux d'IN postopératoires s'est établi à 6,62 % (C, 3,68 %; CC, 9,90 %; S, 16,67 %). La durée moyenne de l'intervention chirurgicale était significativement plus longue chez les patients qui avaient une ISC ou une IN que chez ceux qui n'avaient pas d'infection, pour les cas CC (133 ± 95 c. 78 ± 60 min, $p < 0,05$, et 129 ± 82 c. 77 ± 60 min, $p < 0,001$ respectivement) et S (130 ± 96 c. 82 ± 62 min, $p < 0,001$ et 136 ± 92 c. 80 ± 60 min, $p < 0,001$ respectivement). On a constaté des taux significativement plus élevés d'ISC et d'IN chez les patients qui présentaient des résultats 2 et 3 combinés de l'American Society of Anes-

thesiologists (ASA) que chez ceux qui avaient un résultat 1 dans la catégorie S (χ^2 = 5,06 et χ^2 = 6,34 respectivement). Les taux d'ISC et d'IN étaient aussi beaucoup plus élevés chez les patients qui avaient une échelle de comorbidité combinée de 1 à 6 que chez ceux qui n'avaient aucun facteur de comorbidité dans les cas CC (χ^2 = 4,14 et χ^2 = 4,42 respectivement) et S (non significatif et χ^2 = 4,04 respectivement).

Conclusion : Les taux d'ISC au Centre des soins de santé du Pontiac se comparaient aux taux calculés dans les études multicentriques. On a établi un lien entre la catégorie de contamination de la plaie, le type d'intervention chirurgicale et sa durée, le résultat ASA et l'échelle de comorbidité, d'une part, et les taux d'ISC et d'IN, de l'autre. Les études ont démontré que l'analyse des taux d'IN les réduit en sensibilisant davantage les intéressés et c'est pourquoi nous suggérons que les hôpitaux ruraux mettent en œuvre des protocoles afin de suivre leurs taux d'IN postopératoires.

Introduction

Individual caregivers and institutions must strive to identify and evaluate the quality of care in their milieu in order to rectify recurring problems and improve health care. Postoperative nosocomial infections (NIs) are the single most common class of complication that can reach excessive levels while attracting very little attention.[1] Many health care providers and organizations such as the US Centers for Disease Control and Prevention (CDC), the Joint Commission on Accreditation of Healthcare Organizations and the Surgical Infection Society, consider that periodic audits of postoperative NIs should be mandatory because surveys of this nature decrease infection rates by raising awareness of the issue.[2] Unfortunately, economic constraints make it difficult to perform such studies.

In this article, we compare postoperative surgical site infection (SSI) rates at the Pontiac Health Care Centre (PHCC), a rural hospital, to postoperative SSI rates obtained from large institutions such as the CDC, National Research Council, and large tertiary care centres. We also examine postoperative NI rates and various factors associated with increased risk of infection.

Definitions of postoperative surgical infections

In 1992, a standardized definition of SSIs was published by the Surgical Wound Infection Task Force. This definition includes: the presence of purulent drainage; spontaneous drainage of fluid from the wound, regardless of whether it is culture positive for bacteria; localized signs of infection for superficial sites or radiologic evidence of infection for deep sites; an abscess or other type of infection on direct surgical exploration; or a diagnosis of an infection by a surgeon.[3] Furthermore, SSIs have been categorized by the CDC into 3 categories: superficial, deep, and organ/space infections.[3] Superficial infections involve the skin or subcutaneous tissue; deep infections involve the muscle or fascia; and organ/space infections involve the body cavity such as the pleural cavity or liver bed.[4]

More than 30 years ago, the National Research Council developed a system for categorizing incisions based on the degree of contamination of the incision.[5,6] The original classification was based on 4 categories: clean, clean-contaminated, contaminated, and dirty; but the contaminated and dirty categories were later amalgamated and are referred to herein as "dirty" (Table 1[7,8]).

NIs are hospital-acquired infections that develop within a hospital or are acquired within a hospital.[9] The most common type of NI is urinary tract infection,[10] followed by pneumonia,[11] wound infection, and *Clostridium difficile*–associated diarrhea.[12] On surgical services, urinary tract infections are the most common, followed by SSI, lower respiratory infection and bacteremia.[9]

Surgical site infection risk factors

The Simple Multivariate Risk Index is a prediction equation for surgical wound infections based on 58 498 randomly selected hospitalized patients from the Study on the Efficacy of Nosocomial Infection Control (SENIC) database.[13] Several risk factors for increased infection rate were found. These factors were: abdominal operation ($p < 0.0001$), contaminated or dirty case by the traditional wound classification system ($p < 0.0001$), length of surgery >2 hours ($p < 0.0001$) and more than 2 medical diagnoses ($p < 0.0001$).[13] The original description of patient diagnoses includes the primary diagnosis for surgery. Since the original study, this description was redefined to exclude the primary surgical diagnosis and renamed the Comorbidity Scale.[13]

The Composite Risk Score was developed by the National Nosocomial Infection Surveillance (NNIS) study, and it attempted to improve on the Simple Multivariate Risk Index.[13] The NNIS study comprises nearly 300 US hospitals, and the last published summary was of data collected between January 1990 and May 1999 and was published in June 1999. This study shows that the risk factors associated with an increased wound infection are a contaminated operation, a lengthy operation, and an American Society of Anesthesiologists (ASA) score of 3.[14] ASA scores are categorized into 4 classes: Class I — normal healthy person; Class II — patient with mild systemic disease; Class III — patient with severe systemic disease that limits activity but is not incapacitating; Class IV — patient with an incapacitating systemic disease that is a constant threat to life; and Class V — moribund patient who is not expected to survive 24 hours with or without surgery.[15] It is unclear whether the Composite Risk Score is more predicitive of SSI than the Simple Multivariate Risk Index.[1]

Literature review

We performed a literature review of journal articles published between January 1975 and January 2004 using HealthStar/Ovid HealthStar with the query of "nosocomial infection" combined with the query of "surgical wound infection" as the key words. We then limited the selection to "human" and "English" and obtained 170 citations. Of these studies, the United States,[14] Italy,[16] Germany[17,18] and France[7] were countries found to have national registries for nosososcomial infections. In addition, the United States,[2,8,19] Belgium,[20,21] Ethiopia,[22] Czechoslovakia[23] and Latvia[24] were found to have surgical infection studies done at tertiary care centres. However, there were no published studies that specifically examined surgical infection rates at rural hospitals.

Methods

Setting

The PHCC is a rural hospital located in Shawville, Que. It has a population of about 1500 people and serves a catchment area of about 15 000. It is a 1-hr drive to Ottawa, Ont. The PHCC has 38 acute-care beds. There are 2 full-time general surgeons, 1 visiting gynecologist, 1 visiting otolaryngologist, and 2 visiting ophthalmologists who operate at the hospital. The study proposal was approved by the Council of Physicians, Dentists and Pharmacists of the PHCC.

Study population

A systematic chart review was carried out of all surgical interventions (*n* = 1144) performed in the operating room between October 2001 and March 2003 at the PHCC, as recorded in the operating room log book. Ophthalmological procedures (*n* = 261) were excluded from the study due to a high volume of cases and extremely low occurrence of infection. Surgeries not involving an incision (*n* = 5) such as dilatation and curettage and closed reductions were also excluded.

Variables of concern

For each case, a case number was assigned and in-

Table 1. National Research Council categorization of incisions

Category	Definition	Examples	Accepted infection rates
Clean	Wounds that are non-traumatic and/or do not enter the digestive, respiratory or genital urinary tract. These cases involve only the skin and sterile body spaces without breaks in sterile technique.	Breast surgery Inguinal hernia repair Carpal tunnel release	1%–5%
Clean-contaminated	Wounds in which the digestive, respiratory or genitourinary system is entered, without visible contamination and without obvious infection. These cases involve nonsterile viscera, which have a relatively low level of bacterial colonization.	Bilary surgery Bowel surgery with prepared bowel Hysterectomy Tonsillectomy	5%–10%
Dirty	Wounds in which there is visible contamination from a hollow viscous or are clinically infected. These cases involve exposure to high levels of bacteria.	Excision of perforated appendix/bowel Drainage of abscess	10%–40%

Information compiled from references 7 and 8.

patient and out-patient charts were reviewed to record the study variables. The type of procedure and the degree of contamination of each case was determined from the operative report. The duration of the surgery, as recorded by the nursing staff, and the ASA score, as recorded in the anesthesia record, were noted. The comorbidity factors were collected from admission histories, anesthesia records and discharge summaries. The occurrences of postoperative infections, as recorded in the patient charts, were noted. The minimum postoperative follow up for any case was 3 months.

Statistical analysis

Microsoft Excel 97 was used to calculate rates. The mean duration of length of surgery among patients with and without SSIs and with or without NIs in each contamination category were compared using Student's *t* test with 95% confidence interval (CI). Infection rates between patients with ASA Class I and patients with combined ASA Class II and III in each contamination category were compared using the chi-squared (χ^2) with 95% CI. Infection rates between patients with Comorbidity Scale 0 and those with combined Comorbidity Scale 1–6 in each contamination category were compared using the χ^2 with 95% CI. ASA scores II–III and the Comorbidity Scales 1–6 were combined in order to eliminate falsely elevated χ^2 values.

Results: Chart review and comparison to literature

A total of 831 cases were studied (Table 2). Variables recorded for the study are listed in Table 3.

Infection rates according to wound contamination category

The overall SSI rate was 5.54% (Table 4). SSI rates of 3%–5% are reported in the United States.[6] Lower SSI rates are also reported: a national Belgian study[20] reported an SSI rate of 1.47% and a multi-centre Italian study[16] found an SSI rate of 2.7%. However, Weiss and colleagues[2] showed that 70% of NNIS hospitals did not perform post-discharge SSI surveillance and that 13%–61% of infections only become apparent after discharge. Indeed, the Belgium and the Italian studies did not analyze post-discharge SSI infection rates. It is important to note that the omission of post-discharge infections will falsely decrease SSI rates. In our study, all post-discharge infections were included in the calculation of SSI rates.

SSI rates in clean cases was 3.50%, clean-contaminated cases was 6.77%, and dirty cases was 14.58% compared with rates of 1%–5%, 5%–10%, and 10%–40%, respectively.[6] Our relatively low rate of infection in dirty cases may be due to cautious perioperative surgical management of these cases. For example, patients with overwhelming sepsis due to abscesses are transferred preoperatively to tertiary care centres for ventilatory support and dialysis.

The overall postoperative NI rate was 6.62%. In hospitalized patients, the prevalence of NIs is 5%–10%.[25] The CDC determined that NI rates were greatest on surgical services.[26] Our overall postoperative NI rate is similar to those found in the literature.

Table 3. Variables recorded in the Post-operative Nosocomial Infection Rates study

1.	Case number
2.	Patient name and unit number
3.	Wound contamination classification
4.	Type of surgery
5.	Duration of surgery
6.	American Society of Anesthesiologists score
7.	Number of confounding medical problems
8.	Number of post-operative nosocomial infections
9.	Type of nosocomial infections

Table 2. Description of the 831 cases of surgical intervention chosen for the study, performed at the Pontiac Health Care Centre between October 2001 and March 2003

	Type of surgery							
Category	General	Gynecology	Urology	ENT	Orthopedic	Plastic	Vascular	Total
Clean	211	110	93	22	41	55	11	543
Clean-contaminated	113	22	2	49	2	2	2	192
Dirty	81	4	0	5	3	2	1	96
Total	405	136	95	76	46	59	14	831

ENT = Ear, nose and throat

Infection rates according to type of surgery

SSI rates were found to be highest in vascular cases because of the rate of infection in amputations due to arterial compromise (2 cases, data not shown) (Table 5). In their study, Hopf and coworkers[27] reported that host factors such as poor tissue oxygenation increase the risk of infection. The 12 cases involving venous compromise did not have any infections.

Urological cases had a high degree of SSIs (7.37%), considering that 98% of urology cases were clean cases (Table 2, Table 5). The majority of these cases were vasectomies. It is reported that the average infection rate ranges from 3.4%–38%.[26] We think that this higher infection rate is due to favourable conditions for bacterial proliferation.

General surgery also had a high SSI rate (7.16%) compared with the other surgical specialties (Table 2, Table 5) This can be explained by the high number (48%) of clean-contaminated and dirty cases. Indeed, SSI rates in general surgery clean cases were 3.79%, in clean-contaminated cases 7.96% and in dirty cases 14.81% (data not shown), all similar to reported rates in the literature.[6]

Ear, nose and throat (ENT) had an SSI rate of 2.63%, a low rate considering that only 29% of ENT cases were clean cases (Table 2, Table 5). We can relate this low infection rate to the high degree of oxygen tension in the richly vascular head and neck area.[27] In addition, the mean duration of ENT procedures is short (5 min), which minimizes infections.

Mean duration of surgery

Cases with SSIs were found to have an increased mean duration of length of surgery in all contamination categories (Table 6). However, there was no statistical significance among clean cases with SSIs and NIs. This is probably related to the very low prevalence of infection in clean cases. Indeed, the Simple Multivariate Risk Index study showed that surgery lasting longer than 2 hours increases risk of infection.[13] In our study, we found that the mean duration of surgery in all clean cases, non-infected clean-contaminated and dirty cases were all <2 hours. In contrast, the mean duration of surgery among infected clean-contaminated and dirty cases was >2 hours.

ASA score and Comorbidity Scale score

The rate of infection was found to be directly related to ASA scores in each contamination category (Table 7, Table 8). The Composite Risk Score shows that an ASA score of III increases the risk of infection.[13] In our study, ASA II and III rates were combined due to the limited number of patients with an ASA III score. An ASA score >I was associated with a statistically higher SSI rate in dirty cases and also a statistically higher NI rate in clean and dirty cases.

The Comorbidity Scale was associated with SSI rates in clean-contaminated cases and with NI rates in clean-contaminated and dirty cases. The Simple Multivariate Risk Index shows that a Comorbidity

Table 4. Surgical site and nosocomial infection rates, by wound classification category

Type of infection	Category: Clean n = 543	Clean-contaminated n = 192	Dirty n = 96	Total n = 831
Surgical site (and rate)	19 (3.50)	13 (6.77)	14 (14.58)	46 (5.54)
Nosocomial (and rate)	20 (3.68)	19 (9.90)	16 (16.67)	55 (6.62)

Table 5. Rates of surgical site and nosocomial infections based on surgical subspecialty

Type of infection	Subspecialty: General n = 405	Gynecology n = 136	Urology n = 95	ENT n = 76	Orthopedic n = 46	Plastic n = 59	Vascular n = 14	Total N = 831
Surgical site (and rate)	29 (7.16)	3 (2.21)	7 (7.37)	2 (2.63)	2 (4.35)	1 (1.69)	2 (14.29)	46 (5.54)
Nosocomial (and rate)	36 (8.89)	5 (3.68)	7 (7.37)	2 (2.63)	2 (4.35)	1 (1.69)	2 (14.29)	55 (6.62)

ENT = Ear, nose and throat

Table 6. Comparison of mean duration of length of surgery for patients with surgical site infection versus those without, and patients with nosocomial infection versus those without

Type of infection, and category	Patients with infection		Patients without infection		
	No. of cases	Mean duration, min (and SD)	No. of cases	Mean duration, min (and SD)	*p* value
Surgical site					
Clean	19	63 (39)	524	55 (46)	>0.2
Clean-contaminated	13	133 (95)	179	78 (60)	<0.05*
Dirty	14	130 (96)	82	82 (62)	<0.001*
Nosocomial					
Clean	20	65 (39)	523	55 (46)	>0.2
Clean-contaminated	19	129 (82)	173	77 (60)	<0.001*
Dirty	16	136 (92)	80	80 (60)	<0.001*

SD = standard deviation
* Significant at 95% confidence interval.

Table 7. Comparison of surgical site and nosocomial infection rates between patients whose charts indicated an American Society of Anesthesiologists (ASA) Class I or an ASA Class II–III score

Type of infection, and category	ASA Class I score		ASA Class II–III score		
	Patients with infection	Patients without infection	Patients with infection	Patients without infection	χ^2 value
Surgical site					
Clean	6	238	13	286	1.42
Clean-contaminated	4	94	9	85	2.29
Dirty	1	31	13	51	5.06*
Nosocomial					
Clean	7	237	13	286	8.03*
Clean-contaminated	6	92	13	81	3.20
Dirty	1	31	15	49	6.34*

*Significant at 95% confidence interval.

Table 8. Comparison of surgical site and nosocomial infection rates between patients whose charts indicated a Comorbidity Scale (CS) score of 0 or a CS score of 1–6

Type of infection, and category	Comorbidity Scale score 0		Comorbidity Scale score 1–6		
	Patients with infection	Patients without infection	Patients with infection	Patients without infection	χ^2 value
Surgical site					
Clean	8	304	11	220	2.25
Clean-contaminated	5	118	8	61	4.14*
Dirty	4	42	10	40	2.46
Nosocomial					
Clean	9	303	11	220	1.57
Clean-contaminated	8	115	11	58	4.42*
Dirty	4	42	12	38	4.04*

*Significant at 95% confidence interval.

Scale score of at least 2 increases the risk of infection.[13] We find that having a Comorbidity Scale score of 1 in these categories increases the risk of infection. Differences in infection rates in clean cases were statistically non-significant due to low infection rates in this category. We combined patients with comorbidities into 1 group.

Discussion: limitations of study

Loss of patients to follow up

We think that the loss of patients to follow up in our rural setting is quite low. In our institution, postoperative patients are seen by their surgeon according to a standard protocol 3 weeks after surgery, and the occurrence of infection during this time would be recorded. In addition, our institution facilitates accessibility to surgeons through the emergency department and clinics at any time after their surgery. Consequently, patients would rarely travel 1 hour to the next nearest hospital for another consult.[28] If patients required postoperative medical or surgical care at a tertiary care institution, they would be referred by their treating surgeons and this would be documented.

Small sample size

Our study population comprises roughly 1% of the number of cases in the SENIC and NNIS studies. When analysis of some subpopulations are made (i.e., infection rates according to type of surgery) the study numbers are small. Thus, conclusions drawn from these rates may be limited.

As well, due to a low number of infected cases in our study population, we combined patients with ASA scores II and III and Comorbidity Scale scores between 1 and 6 inclusively. The low number of infected cases in our study population could be related to the exlusion of infected cases that require prolonged intubation, invasive monitoring or dialysis. These cases are transferred preoperatively to a tertiary care centre.

Non-quantifiable risk factors for infections

Factors such as antibiotic prophylaxis and skin preparation[4] have been determined to be important in other studies, but are difficult to quantify retrospectively and are thus not included in various scoring or classification systems and were not analyzed in this study.

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Competing interests: None declared.

Conclusion

SSI rates and the NI rate at PHCC were comparable to multicentre rates. This study validates various factors that contribute to increased infection rates such as type of procedure, degree of contamination, duration of surgery, ASA score and Comorbidity Scale score as found in the Simple Multivariate Risk Index and the Composite Risk Score. In addition, the SENIC project suggests that raising awareness for infection control decreases infection rates. We suggest that other rural hospitals survey their postoperative infection rates and implement protocols adapted to the context of their institution to limit their infection rates.

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