Incidence and Time Trend of Surgical Site Infection in Ramathibodi Hospital during the Years 2003-2005

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Objective: *To determine the incidence of surgical site infection (SSI) for high-risk surgical procedures and any changes in the incidence of SSI during the years 2003 to 2005.*
Material and Method: *SSI surveillance data were obtained from Ramathobodi's Infection Control Committee for analysis.*
Results: *The overall 30-day incidence of SSI for 492 hepato-biliary-pancreas and colon procedures was 7.7% (38 of 492). Of the 38 SSIs, only 35 were analyzed in detail. Most patients had SSI types I and II, 89% of SSIs were detected within 20 days after operation, and most common organisms isolated were enterococcus species, E.coli, and P. aeruginosa. SSI rate for the year 2005 (11%) was significantly higher than that of the preceding years (4-5%).*
Conclusion: *Overall, SSI rates for Ramathibodi Hospital were not significantly different from those of other studies. The increased SSI rate for the year 2005 needed an explanation, but the value of the present report lies in the potential usefulness of the presented results for future prevention of SSIs.*

Keywords: *Incidence, Surgical site infection*

J Med Assoc Thai 2007; 90 (7): 1356-62
Full text. e-Journal: *http://www.medassocthai.org/journal*

Surgical site infection (SSI) surveillance has been shown to reduce the incidence of SSI[1-3]. This benefit was the aim of the SSI surveillance program begun in 2003 by the Infection Control Committee of Ramathibodi Hospital. From the beginning, due to lack of resources and personnel, the program was targeted towards "high-risk" surgical procedures. These were defined in an organ-oriented manner as those procedures at the highest risk of developing SSI. The surveillance methods were necessarily limited to a retrospective review of medical charts[4], but post-discharge surveillance was readily achieved during the review. The objective of the present report was to present the incidence of SSI in Ramathibodi Hospital and the changes in the incidence of SSI during the first two and a half years (2003 to 2005) after the institution of the surveillance program.

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Material and Method

Data from Ramathibodi Hospital's targeted SSI surveillance program during the period between July 2003 and December 2005 were obtained for analysis. Definitions of SSI used by Ramathibodi Hospital's Infection Control Committee (ICC) were those of the National Nosocomial Infection Surveillance (NNIS) system[2], as developed by the Centers for Disease Control and Prevention (CDC), the US Department of Health and Human Services (DHHS). Surgical procedures targeted for surveillance were those associated with the highest incidence of SSI according to a previous cohort study[5]. These procedures were done on the liver, pancreas, biliary tract, and colon. Laparoscopic cholecystectomy was excluded from the survey. The surveillance method was by retrospective chart review of cases operated on at least one month prior to review. The procedures were identified using the ICD-9 codes in the Hospital's computerized database.

Data abstracted included age, diagnosis, NNIS risk index (calculated from the ASA classification, duration of surgery and wound classification)[4], type of procedure, the operating surgeon, location of operating room suite, occurrence of SSI, type of SSI, organisms isolated from the infection site, date of admission, date of operation and date of SSI diagnosis. Patients undergoing multiple procedures, defined as procedures on more than one organ system during an operation, were not surveyed until the beginning of 2005. Since emergency procedures were not labeled as such in the ICC's surveillance data until 2005, the information on emergency procedures was not used in the present study. The incidence of SSI was defined as the "30-day" rate of infection, where the latter was calculated as the number of persons diagnosed to have SSI within 30 days of their primary operation performed

Table 1. Characteristics of patients and operations, with and without SSI

Characteristics[a]	Total (n = 458 operations)[b]	Without SSI (n = 423 operations)	With SSI (n = 35 operations)[c]
Age (years): mean (SD)	59.4 (14.6)	59.6 (14.4)	57.5 (17.2)
Gender (males)	223 (49%)	205 (49%)	18 (51%)
Preoperative stay (days):			
Median (range)	2 (1 to 68)	2 (1 to 63)	2 (1 to 68)
ASA class			
I	17 (4%)	17 (4%)	0
II	190 (41%)	182 (43%)	8 (23%)
III	193 (43%)	174 (41)	21 (60%)
IV	55 (12%)	49 (12%)	6 (17)
V	1 (0)	1 (0)	0
Wound classification			
Clean[d]	41 (9%)	37 (9%)	4 (11%)
Clean-contaminated	371 (81%)	348 (82%)	23 (66%)
Contaminated	26 (6%)	23 (5%)	3 (9%)
Dirty	20 (4%)	15 (4%)	5 (14%)
Duration of surgery (minutes):			
Median (range)	130 (30 to 615)	120 (30 to 550)	150 (60 to 615)
NNIS index			
0	140 (31%)	139 (33%)	1 (3%)
1	220 (48%)	203 (48%)	17 (49%)
2	88 (19%)	74 (17%)	14 (40%)
3	10 (2%)	7 (2%)	3 (9%)
Cancer (yes)	248 (55%)	235 (56%)	18 (51%)
Operations on Organs			
Gall bladder	137 (30%)	121 (31%)	8 (23%)
Biliary tract	48 (11 %)	38 (9%)	10 (29%)
Colon	220 (48%)	205 (49%)	15 (43%)
Liver	37 (8%)	35 (8%)	2 (6%)
Pancreas	16 (3%)	16 (4%)	0
Older operating theaters (> 12 yrs)	307 (67%)	282 (67%)	25 (71%)

a: Values are number (%) unless stated otherwise; b: Operations with complete data only were analyzed (458 of 492); c: Infections with complete data only were analyzed (35 of 38); d: Also included in the clean wound classification were procedures that did not involve grossly entering the gastrointestinal tract or those that entered the biliary tree or pancreatic ductal system only peripherally, such as during liver or pancreatic biopsy or distal pancreatectomy within a given time period divided by the total number of targeted operations within the same period. In practice, SSI detected after 30 days (but none further than 50 days) were also included, but these were few.

The change in the incidence of SSI was shown by comparing incidences calculated for each year in the period under study. Potential confounders such as infection risk, age, gender, type of procedure and duration of preoperative stay were also taken into account. Comparison of the observed procedure/risk index-specific SSI incidences with the NNIS infection rates was also made. The NNIS procedure[6,7]/risk-specific infection rates were obtained for the year 2004[7]. A measure of how well the NNIS risk index can predict subsequent observed SSI (see below) was also calculated.

Statistical methods

Continuous data were summarized as mean (standard deviation) or median (range) as appropriate. Categorical data were summarized as counts and percentages. Estimation of the time-to-infection curve was done using the Kaplan-Meier method. Comparing the observed procedure-specific SSI rates with those of the NNIS data was done using the Freeman-Tukey statistic[8] which was advocated by the developers of the NNIS system[6]. The discriminatory ability of the NNIS risk index in distinguishing patients who will have SSI from those who will not was measured using the Area under the Receiver Operating Characteristic Curve (AUC). The association between SSI and, year of surveillance, in terms of risk ratios (RR), whether adjusted for potential confounders or not, was estimated, using Poisson regression. The outcome of each operation in a series of operations on any one patient was considered to be correlated with one another, and this was taken into account in the analysis by including a gamma-distributed random effects term[9] in the Poisson model. The Wald statistic was used to test the significance of a time trend. Statistical significance was defined as a p-value of 0.05 or less. Statistical analysis was done using STATA version 7 software (STATA Corp, College Station, TX, USA).

Results

Four hundred and ninety-two targeted operations were performed during the period between July 2003 and December 2005. Data on 458 operations (93%) in 453 patients were available for review. Characteristics of the patients and operations surveyed are displayed in Table 1. Almost 80% (360 of 458) of all operations had a NNIS risk index of 0 or 1. Thirty-eight SSIs were detected out of 492 operations (7.7%) for that period, but only 35 SSIs out of 458 (7.6%), had available full clinical information. Most of the SSIs (31 of 35 or 89%) occurred within 20 days of primary surgery. A Kaplan-Meier estimate of the infection-free probability curve is presented in Fig. 1. Slightly more than half of all SSI patients had abdominal wound infection; the rest had intra-abdominal abscess or both wound infection and intra-abdominal abscess. Of the 38 SSIs 36 (95%) had culture results and organisms were identified in 34 (Table 2). The most common organisms identified were *enterococcus* species, *E. coli*, and *Pseudomonas aeruginosa*. *Staphylococcus aureus* was identified in only 7% of specimens.

The NNIS index was the best single predictor of the occurrence of SSI. The AUC value as a measure of the index of discriminatory ability was 0.764 (95% CI: 0.684 to 0.844).

The SSI rates in the years 2003, 2004 and 2005 were 5.3% (4/76), 4.2% (7/168) and 11.2% (24/214), respectively. There seemed to be a significant two-fold increase in the incidence of SSI in the year 2005 (Wald

Table 2. Type of SSI, time to infection and organisms isolated

Outcome : Summary	N (%)
SSI: number (%)	38
Total SSIs with complete data	35/38 (92)
Type of SSI	
Type I : number (%)	14/35 (40)
Type II: number (%)	5/35 (14)
Type III: number (%)	16/35 (46)
Time to SSI (days)	
Mean (SD)	12.3 (10.2)
Median (range)	8 (3 to 45)
Organisms from infection site	
Total number of isolates	55
Enterococcus spp.: number (%)	15/55 (27)
Escherichia coli: number (%)	14/55 (25)
Pseudomonas aeruginosa: number (%)	8/55 (15)
Acinetobacter baumanii (MDR): number (%)	5/55 (9)
MRSA: number (%)	4/55 (7)
Candida albicans: number (%)	2/55 (4)
Others: number (%)	7/55 (13)

MDR: Multi-Drug Resistance; MRSA: Methicillin-Resistant *Staphylococcus Aureus*; Type I SSI refers to skin and subcutaneous tissue infection at the incision site; Type II SSI refers to infection of fascia and muscle of the surgical incision; and Type III SSI refers to organ space infection

Table 3. Multivariable analysis of risk factors associated with SSI (Poisson regression)

Risk factor	Risk Ratio	95% CI	p-value
Risk index	2.70 per cat	1.76 to 4.15	<0.001
Year 2005	2.44	1.13 to 5.25	0.022
Multiple procedures	0.91	0.32 to 2.56	0.898
Cancer	0.75	0.33 to 1.72	0.503
Age	0.98 per year increase	0.96 to 1.00	0.122
Gender (male)	0.97	0.49 to 1.91	0.926
Older Theaters (> 12 yrs)	2.11	0.88 to 5.03	0.094
Preoperative stay	1.02per day increase	0.98 to 1.06	0.275
Operated organ-system			
Gall bladder	1	-	-
Biliary-liver-pancreas	2.16	0.72 to 6.50	0.170
Colon	1.41	0.49 to 4.04	0.519

Table 4. Comparison between NNIS risk/procedure-specific SSI rates (in percent) and observed rates (single procedure only)

Procedure	NNIS risk index	NNIS expected rate	Observed rate 2003-2005	p-value*
Colorectal surgery	0	3.98	1.35 (1/74)	0.644
	1	5.66	8.42 (8/95)	
	2	8.54	7.14 (2/28)	
	3	11.25	33.33 (2/6)	
Opened cholecystectomy	0	0.68	0 (0/50)	0.008
	1	1.78	3.45 (2/58)	
	2	3.27	23.8 (5/21)	
	3	5.68	25 (1/4)	
Biliary tract-liver-pancreas	0	3.11	0 (0/13)	0.222
	1 & 2	7.37	12.5 (9/72)	

* p-values by Freeman-Tukey statistic

statistic p-value = 0.012). This increase remained significant after adjusting for infection risk, age, multiple procedures, duration of pre-operative stay, cancer, and operating theater (Table 3). Comparing the observed procedure/risk-specific SSI incidence (single procedure only) with that of the NNIS data, there was a significant difference regarding the open cholecystectomy procedure (Table 4).

Discussion

SSI surveillance for the purpose of nosocomial infection control requires only that there be standard infection rates with which to compare and a reliable and accurate surveillance procedure such that a trend in time can be detected(6,10,11). From this point of view, a targeted surveillance program is probably sufficient; by concentrating on operative procedures with higher infection rates, survey efficiency can be achieved at an affordable cost. The basic assumption is that surveillance of high-risk operative procedures is representative of all operative procedures.

Although only 35 SSIs in 458 operations were used in the analysis instead of the actual 38 SSIs in 492 operations, the results of the analysis probably would not have changed otherwise. This is because the number of SSIs and number of operations with missing information were relatively few and the reason for the occurrence of missing information was not clearly related to the occurrence of SSI.

The overall incidence of SSI for high-risk abdominal operations in the present report was similar to that seen in the literature(6,10). Similarly, the finding that

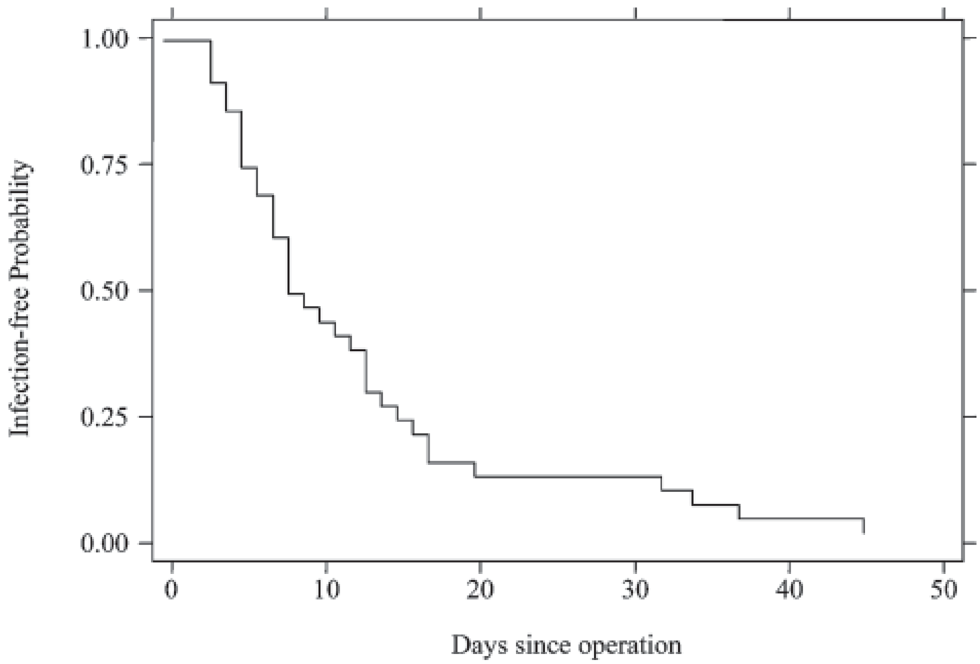

Fig. 1 Kaplan-Meier estimate of the SSI-free curve for patients with subsequent SSI

most SSI occurred within 20 days after operations was in accordance with previous studies[2,4]. The apparently high incidence of SSI (most of which were superficial wound infections) for higher risk cholecystectomy procedures might need to be explained, especially when such high incidence was not seen for concurrent colon procedures. No definite explanation can be provided at present. Statistically, since the number of operations for higher risk patients (NNIS index > 1) was small, this difference could have occurred by chance.

The CDC definitions of the various types of SSIs have not been as reliable as may be expected in real practice[10-12]. Different interpretation of the definitions and the inherently subjective nature of some criteria (e.g. infection can be established by a surgeon's judgment that there is an infection, without any other corroborating evidence)[11] as well as major differences in the methods of SSI surveillance[10], can give rise to wide variation in infection rates.

The NNIS index was the best single predictor of SSI in the present study. An AUC of 0.76 was rather low (a "good" AUC is over 0.8). However, this only reflects that other prognostic factors may need to be taken into account[13,14].

The frequencies of microorganisms isolated from the sites of infection were in accordance with those associated with hepatobiliary-pancreas and colon procedures[2].

The two-fold higher overall incidence of SSI for the year 2005 also needed to be explained. However, since these data were analyzed one year after the fact, a reliable search for causes of this change could not be done. Nonetheless, according to the present analysis, the higher incidence of SSI could not be explained by increased risk of infection, age, gender, multiple procedures, pre-operative stay, cancer co-morbidity, and in particular, the operating theaters in which some of the operations were performed. Explanations having to do with operating room renovation during the year 2005 are thus not supported by the present data.

The survey method used in the present study, i.e. retrospective chart review, has been found to be 80% sensitive relative to direct wound surveillance[4]. Although a chart review method can detect post-discharge SSI, the relative proportions of SSI types seen in the present study (Table 2) seem to indicate that most infections were in fact detected prior to hospital discharge[6]. For the purpose of detecting changes in SSI rates, however, chart review methods may be sufficient.

SSI surveillance with proper feedback to surgical personnel caring for patients should help reduce the risk of infection[1-3]. The data collected by the hospital's ICC must be analyzed and presented in a form that is readily interpretable by these personnel. Particularly useful is the presentation of time-serial SSI incidence. A time trend is easily seen and may invite an investigation into the causes of such a trend. Unfortunately, the feedback so far has not been done in the manner presented. It is also likely that the raw numbers provided to each surgical unit every year were ignored.

It is suggested that presentation of SSI statistics in the form provided in this review could be easily assimilated in clinical practice (Tables 1, 2, and 4 for each year under comparison). A slowly changing trend in infectious complications can only be seen when annual rates are compared[10]. Any tendency towards an increase can be traced to any specific subgroup of operations and investigated in detail. Preventive measures can then be instituted as appropriate.

Conclusion

SSI surveillance data was presented and the incidence of SSI was compared with previous studies and standard rates. A trend towards higher SSI rates was seen for the year 2005 compared with previous years. Although no plausible causative factors for this difference could be determined from the available data, the detection of such differences is potentially useful for future prevention of SSIs.

References

1. Haley RW, Culver DH, White JW, Morgan WM, Emori TG, Munn VP, et al. The efficacy of infection surveillance and control programs in preventing nosocomial infections in US hospitals. Am J Epidemiol 1985; 121: 182-205.
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: 250-78.
3. Delgado-Rodriguez M, Gomez-Ortega A, Sillero-Arenas M, Martinez-Gallego G, Medina-Cuadros M, Llorca J. Efficacy of surveillance in nosocomial infection control in a surgical service. Am J Infect Control 2001; 29: 289-94.
4. Roy MC, Perl TM. Basics of surgical-site infection surveillance. Infect Control Hosp Epidemiol 1997; 18: 659-68.
5. Putwatana P, Reodecha P, Sirapo-ngam Y, Lertsithichai P, Sumboonnanonda K. Nutrition screening tools and the prediction of postoperative infectious and wound complications: comparison of methods in presence of risk adjustment. Nutrition 2005; 21: 691-7.
6. Gaynes RP, Culver DH, Horan TC, Edwards JR, Richards C, Tolson JS. Surgical site infection (SSI) rates in the United States, 1992-1998: the National Nosocomial Infections Surveillance System basic SSI risk index. Clin Infect Dis 2001; 33(Suppl 2): S69-S77.
7. National Nosocomial Infections Surveillance (NNIS) System Report, data summary from January 1992 through June 2004, issued October 2004. Am J Infect Control 2004; 32: 470-85.
8. Agresti A. Asymptotic theory for parametric models: notes, problem. In: Agresti A, editor. Categorical data analysis. 2nd ed. New Jersey: Wiley; 2002: 594-5.
9. Agresti A. Poisson regression with random effects. In: Agresti A, editor. Categorical data analysis. 2nd ed. New Jersey: Wiley; 2002: 563-5.
10. McLaws ML, Caelli M. Pilot testing standardized surveillance: Hospital Infection Standardised Surveillance (HISS). On behalf of the HISS Reference Group. Am J Infect Control 2000; 28: 401-5.
11. Wilson AP, Gibbons C, Reeves BC, Hodgson B, Liu M, Plummer D, et al. Surgical wound infection as a performance indicator: agreement of common definitions of wound infection in 4773 patients. BMJ 2004; 329: 720.
12. Wilson JA, Ward VP, Coello R, Charlett A, Pearson A. A user evaluation of the Nosocomial Infection National Surveillance System: surgical site infection module. J Hosp Infect 2002; 52: 114-21.
13. Brandt C, Hansen S, Sohr D, Daschner F, Ruden H, Gastmeier P. Finding a method for optimizing risk adjustment when comparing surgical-site infection rates. Infect Control Hosp Epidemiol 2004; 25: 313-8.
14. Roy MC, Herwaldt LA, Embrey R, Kuhns K, Wenzel RP, Perl TM. Does the Centers for Disease Control's NNIS system risk index stratify patients undergoing cardiothoracic operations by their risk of surgical-site infection? Infect Control Hosp Epidemiol 2000; 21: 186-90.

อุบัติการณ์และแนวโน้มของการติดเชื้อที่ตำแหน่งผ่าตัดในโรงพยาบาลรามาธิบดีระหว่างปี พ.ศ. 2546 ถึง พ.ศ. 2548

ปราณี เคหะจินดาวัฒน์, กำธร มาลาธรรม, กนกวรรณ บุญแสง, ณิชา ศิริพรภิญโญ, เพียรจิตต์ ภูมิศิริกุล, จิณภัค กลกาลกุล, ภาณุวัฒน์ เลิศสิทธิชัย

วัตถุประสงค์: *เพื่อศึกษาอุบัติการณ์ของการติดเชื้อที่ตำแหน่งผ่าตัดในผู้ป่วยที่มีความเสี่ยงสูงที่จะเกิดการติดเชื้อและเพื่อศึกษาการเปลี่ยนแปลงของอุบัติการณ์ของการติดเชื้อระหว่างปี พ.ศ. 2546 ถึง พ.ศ. 2548*

วัสดุและวิธีการ: *วิเคราะห์ข้อมูลที่เก็บโดยคณะกรรมการป้องกันและควบคุมโรคติดเชื้อในโรงพยาบาลของโรงพยาบาลรามาธิบดี*

ผลการศึกษา: *อุบัติการณ์การติดเชื้อที่ตำแหน่งผ่าตัดที่เกิดภายใน 30 วัน หลังผ่าตัด คือร้อยละ 7.7 (38 จาก 492) ในการผ่าตัด ตับ, ทางเดินน้ำดี, ตับอ่อน และลำไส้ใหญ่ รวม 492 ครั้ง ในผู้ป่วย 35 รายจาก 38 รายที่มีข้อมูลครบมีการติดเชื้อตำแหน่งผ่าตัดประเภท I และ II ร้อยละ 89 เกิดการติดเชื้อภายใน 20 วันหลังผ่าตัด เชื้อโรคที่พบบ่อย คือ Enterococci species E.coli และ P.aeruginosa. อุบัติการณ์การติดเชื้อในปี พ.ศ. 2548 คือ ร้อยละ 11 ซึ่งสูงกว่าปีก่อน ๆ (ร้อยละ 4 ถึง 5) อย่างมีนัยสำคัญ*

สรุป: *ในภาพรวมอุบัติการณ์ของการติดเชื้อตำแหน่งผ่าตัดในโรงพยาบาลรามาธิบดีไม่แตกต่างจากสถาบันอื่นมากนัก การติดเชื้อที่เพิ่มมากขึ้นในปีพ.ศ. 2548 ยังไม่มีคำอธิบายชัดเจน แต่ความสำคัญของรายงานนี้อยู่ที่ประโยชน์ของข้อมูลที่นำเสนอในการป้องกันการติดเชื้อในอนาคต*