245

SURGICAL SITE INFECTION IN SONGKLANAGARIND HOSPITAL

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SURGICAL SITE INFECTION IN SONGKLANAGARIND HOSPITAL

Final report of research project
January 1, 2001

Prepared by

Associated Professor Silom Jamulitrat, MD.
Department of Community Medicine
Faculty of Medicine
Prince of Songkla University

Contents

ABSTRACT

Background: Despite advances in operative techniques, better understanding of pathogenesis of wound infection, postoperative surgical site infections continue to be a major source of morbidity and mortality for patient undergoing operative procedures. The patterns of infection in surgical patients varied among hospitals due to characteristics of the patients and type of operation performed. To make the infection surveillance and control programs effective, it is essential to understand the epidemiology of surgical infection in individual hospital.

Objectives:
1. To document the rates of surgical site infections stratified by risk index and operative procedure
2. To identify the common causative pathogens
3. To identified the risk factors for surgical site infection

Material & Methods: A prospective study was employed and included 4,437 major operations performed in 4,193 patients admitted to Songklanagarind hospital. The period of the study was between September 1998 and March 2000. The hospital which the study was conducted is the 650-bed university hospital serving as medical school and tertiary care hospital. The study included the patients of the department of general surgery, neurosurgery, plastic surgery, urosurgery, pediatric surgery, and orthopedic surgery. Pertinent data were collected by two infection control nurses. Diagnosis of hospital acquired infection were done by using CDC criteria.

Results: There were 506 hospital acquired infections recorded including 192 surgical site infections. The most common pathogen responsible for surgical site infection was *Staphylococcus aureus*. The independent risk factors for surgical site infection were:- duration of operation, ASA class, and degree of wound contamination.

Acknowledgements

The author would like to thank Mrs. Somchit Thongpiyapoom and Mrs. Montha Na Narong, the infection control nurses of Infection Control Unit, Songklanagarind Hospital for their helpful assistance in many steps of the study.

INTRODUCTION

It is well accepted that advances in medical technologies on one hand reduce the infection complication in surgical patients. But on the other hand these innovations produce the new population of patients with high risk to infection. Discovery of antiseptics, antibiotics, sterilization and aseptic techniques make the surgery possible and safe for the operation that was once impossible. The more invasive and extensive operations were introduced and resulted in growing a certain population of patients in the hospital. The widespread use of antibiotics is responsible for emerging of multiresistant organisms which created the substantial problems in combating infection. Advances in organ transplantation and in agents to prevent and treat allograft rejection have resulted in a new kind of compromised host. The prosthesis placed in the patients produce the environment that prevent the pathogen from host macrophages.

Because the patient care technologies are continuous developed so the patterns of hospital acquired infection in surgical patients are changing from time to time. It is the essential part of nosocomial infection surveillance programs to periodically document the epidemiologic features of infection acquired in surgical patients.

Although the infection control committee has been established in Songklanagarind hospital since 1986, the latest information concerning infection in surgical patients was in the year 1992. The primary intention this prospective study to identify the epidemiologic features of hospital acquired infection in selected patients. The information gained from this investigation will be used in planning for the future surveillance and control programs.

HISTORY

Prior to 1885, wound infection was a common companion of any surgical procedure, and life-threatening infection was the anticipated outcome of major operations. Once a patients' major defense against infection, the intact skin, was breached by either trauma or the surgical knife, a broad avenue was opened to introduction of virulent bacteria. In hospitals, outbreaks of cellulitis and septicemia swept among postoperative patients, undoubtedly reflecting epidemic spread of virulent streptococci. It is difficult to conceive the terror such infections wrought in patients and hospital personnel alike. Minor skin trauma resulted in cellulitis, which rapidly progressed to lymphangitis, gangrene, bacteremia, and death. This was variously described as streptococcal gangrene or hospital gangrene. Septicemia was a term often employed to describe fulminating cellulitis that arose 2 to 4 days after a traumatic wound (especially a compound fracture or deep soft-tissue laceration) and before suppuration was evident. Death from uncontrolled bacteremia generally occurred in a week. In contrast to these rapidly fatal cellulitic-septicemic episodes, localized purulent infections were virtually welcomed by surgeons. The term laudable pus, no doubt characterizing staphylococcal infections, portrayed a cautious expectation of recovery of a patient despite a suppurating wound. However, local purulent wound infections did have the potential for dissemination, thereby causing death by pyemia.

Joseph Lister is appropriately honored as the surgeon who initiated the scientific process to abolish both the terror and the mystery of surgical infection. The profound impact of Lister on surgical and biologic thinking in relation to surgical infection lasts to the present. The events of his investigations were instructive. He made the great intellectual leap from Pasteur's concept of invisible environment germs causing fermentation and putrefaction to the hypothesis that similar bacteria in the ambient air could cause wound infection if they gained access to tissues through broken skin. Beginning studies in 1865, Lister selected carbonic acid (phenol) as an agent to prevent sepsis (antiseptic). He employed an antiseptic as a chemical shield to maintain the sterility of the operative site. His objective was to prevent tissue invasion of ambient bacteria through an open wound and thus to prevent wound infection. This concept was distinct from that of Semmelweis, who advocated an antiseptic be used on unbroken skin of physicians' hands to prevent them from serving as a vehicle of contact transmission of contagion from cadavers to postpartum women. For Lister, prevention of infection was an all-consuming research objective. He systematically explored the use of carbonic acid in experimental animals to prevent infection following compound fractures and preserved despite initial failures. By 1885, Lister was able to use carbolic acid in human to prevent infection by direct application to the wound site. Despite such success, a number of contemporaries were loath to accept Lister's measures as a regular surgical practice. Later, more vigorous in his efforts to promote a wider atmosphere of antisepsis, Lister nebulized carbonic acid during operations.

Lister great contribution to science was to demonstrate, by sound laboratory and clinical research, a rational approach to understanding the causation of surgical infection based on Pasteur's demonstration of unseen ambient microbiologic world. His revolutionary approach emphasized that microorganisms must be prevent from entering a wound during or after operation, and that if microorganisms were already present in a wound at the time of operation, they must be prevented from spreading. These remain basic concepts in present-day surgery. He also stressed that all instruments, dressings, and everything else in contact with the operative site, including the hands of surgeons and assistants, should be made antiseptic. Moreover, the success of Lister's research efforts permanently fixed the principle of prophylaxis of infection as a practical surgical goal. His focus on prevention though antisepsis eventually gave way to a new school of though emanating from Germany; namely, that the careful surgeon with "surgical clean" hands and sterile instruments could prevent infection without need for chemical disinfection of environment. Studies reported by Robert Koch in 1881, describing the relative merits of dry and moist heat as sterilizing agents, gave impetus to the use of first boiling water and then steam autoclaves to sterilize surgical instruments and surgical dressings. Thus modern surgical aseptic technique was born. Lister eventually agreed that his hypothesis that ambient airborne bacteria were the cause of sepsis was incorrect and that the primary reason for wound infection was the bacterial contamination arising from surgeons' dirty hands and instruments. In current practice, however, vestiges of Lister's antisepsis still remain in the use of antibacterial agents to prepare a patient's skin and in their administration for surgical prophylaxis.

Lister's wound irrigation with phenol, in fact, damaged tissues and delayed wound healing. However, the use of a chemical for antiseptic treatment of contaminated traumatic wounds has been a subject long of interest to military surgeons. Iodine was used in war wounds as early as the 1861 – 1865 American Civil War and sodium hypochlorite solution (Dakin's solution) was employed during World War I. Both iodine compounds and Dakin's solution are now also known to damage tissues, Sulfonamides were employed for local and systemic prophylaxis of traumatic wounds in World War II. A United States National Research Council study conducted in the early 1940s, however, revealed that local use of sulfonamides that had little effect on preventing infection following severe injuries. The goal to eradicate bacteria from contaminated traumatic wounds by chemical measures has proved to be illusory and unattainable, as measured by the failure of such treatments to permit primary wound closure without a considerable risk of infection. What was learned by military surgeons in their studies of antiseptics was the importance of delayed wound closure. Carrell and Dakin popularized local antisepsis, debridement, and delayed closure of traumatic wounds during World War I. Churchill extended these observations on wound closure during World War II and reemphasized the danger of primary closure of contaminated traumatic wounds after seemingly adequate debridement. This lesson, unfortunately, has had to be relearned by subsequent generations of battlefield and trauma surgeons.

During World War II. the efficacy of penicillin treatment for established surgical infections seemed almost miraculous. A variety of life-threatening surgical infections, including cellulitic-septicemic ones, acute suppurative arthritis, acute osteomyelitis, finally became amenable to drug therapy alone. For the first time in history, military surgeons were able to treat virulent infections without an overwhelming case fatality rate without mutilation.

Routine surveillance of surgical infection evolved from the great epidemics of *Staphylococcus aureus* infection in hospital in the late 1940s and 1950s. The World War II vision of easy control of infection by antibiotics gave way to the reality of worldwide outbreaks of antibiotic-resistant *S. aureus*. In addition to antibiotic resistance, these staphylococci generally of the 52/52A/80/81 phage type complex-clearly possessed enhanced virulence, as manifested by epidemics of breast abscess in postpartum women, pustules in newborn infants, and rapid secondary spread of suppurative disease. A 1964 United States National Research Council and National Academy of Science (NRC/NAS) study at five university hospitals, conducted to evaluate the efficacy of ultraviolet light in operating rooms to prevent wound infection, did serve to emphasize the variety of host and operative conditions predisposing to infection. A striking finding was the wide range of differences in frequency of wound infection at the different participating hospitals for similar classes of operations, for example, infection rate varied from 3.5 to 19.6 percent. Cruse and Foord expanded the concept of surveillance from a research activity to one of ongoing assessment. Systematic surveillance of postoperative patients for infection has become a central activity in infection control programs and serves as a benchmark in evaluation of infection control programs by hospital regulatory and accrediting agencies. Especially useful now is the surveillance of specific clean and clean-contaminated operations, which provide a basis for meaningful comparisons. Surveillance of postoperative infection has further evolved into a quality assurance measure in many North American hospitals.

SOURCES FOR PATHOGENS CAUSING SURGICAL SITE INFECTIONS

Pathogens that cause surgical site infections are acquired either endogenously from the patient's own flora or exogenously from contact with operating room personnel or the environment. It is believed that, within 24 hours of an operative procedure, most surgical sites are sufficiently sealed, unless the site was close secondarily or involved drain placement, to make them resistant to inoculation and infection. Thus most pathogens, whether endogenously or exogenously acquired, are believed to be implanted at the time of surgery. Theoretically, the operative site can be seeded postoperatively by the hematogenous or lymphatic route or by direct inoculation of the closed operative site, but such mechanisms of acquisition are thought to occur infrequently.

RISK FACTORS FOR THE DEVELOPMENT OF SURGICAL SITE INFECTION

In 1965, Altemeir stated that the risk of a infection varies (a) directly in proportion to the dose of bacterial contamination, (b) directly in proportion to the pathogenicity of the organism, and (c) inversely in proportion to the resistance of the host, that is, the patient's ability to control the microbial contamination. On the basis of animal studies, we can add a fourth key factor: the physiologic status or condition of the surgical site at the end of the operation. A surgical site in poor condition, that is, one that is poorly vascularized or that contains damaged or necrotic tissue or foreign material, is at a higher risk of infection given the same degree of microbial contamination. Surgical site condition is also determined the underlying disease process that necessitated surgery (e.g., the severity of trauma) and by operative technique (i.e., the skill of the surgeon). These four key factors interact in a complex way to foster the development of infection.

SURGICAL SITE INFECTION RISK STRATIFICATION

Three categories of variables have proven to be reliable predictors of surgical site infection risk: (a) those that estimate the intrinsic degree of microbial contamination of the surgical site, (b) those that measure the duration of an operation, and (c) those that serve as markers for host susceptibility. A widely accepted scheme for classifying the degree of intrinsic microbial contamination of a surgical site was developed by the 1964 NAS/NRC Cooperative Research Study and modified in 1982 by CDC for use in surgical site infection surveillance (**Appendix A**). In this scheme, a member of surgical team classifies the patient's wound at the completion of the operation. Because of its ease of use and wide availability, the surgical wound classification has been used to predict surgical site infection risk. However. two CDC efforts-the SENIC Project and the NNIS system-incorporated other predictor variables into surgical site infection risk indices. These showed that even within the category of clean wounds, the surgical site infection risk varied by risk category from 1.1% to 15.8% (SENIC) and from 1.0% to 5.4% (NNIS). In addition, sometime an incision is incorrectly classified by a surgical team member or not classified at all, calling into question the reliability of the classification.

Data on 10 variables collected in the SENIC Project were analyzed by using logistic regression modeling to develop a simple additive surgical site infection risk index. Four of these were found to be independently associated with surgical site infection risk: (a) an abdominal operation, (b) an operation lasting >2 hours, (c) a surgical site with a wound classification of either contaminated or dirty/infected, and (d) an operation performed on a patient having $\geq$3 discharge diagnoses. Each of these equally weighted factors contributes a point when present, such that the risk index values range from 0 to 4. By using these factors, the SENIC index predicted surgical site infection risk twice as well as the traditional wound classification scheme alone.

The NNIS risk index is operation-specific and applied to prospectively collected surveillance data. The index values range from 0 to 3 points and are defined by three independent and equally weight variables. One point is scored for each of the following when present: (a) American Society of Anesthesiologists (ASA) Physical Status Classification of >2 (**Table 1**), (b) either contaminated or dirty/infected wound classification, and (c) length of operation >75th percentile of duration of the specific operation being performed. The ASA class replaced discharge diagnoses of the SENIC risk index as a surrogate for the patient's underlying severity of illness (host susceptibility) and has the advantage of being readily available in the chart during the patient's hospital stay.

Table 1. Physical Status Classification, American Society of Anesthesiologists

Class	Patient preoperative physical status
1	Normally healthy patient
2	Patient with mild systemic disease
3	Patient with severe systemic disease that is not incapacitating
4	Patient with an incapacitating systemic disease that is a constant threat to life
5	Moribund patient who is not supposed to survive for 24 hours with or without operation

Rationale of the Study

Surveillance of surgical site infection with feedback of appropriate data to surgeons has been shown to be an important component of strategies to reduce surgical site infection risk [1,2]. In the process of planning for surveillance the baseline epidemiologic data must be obtained including infection rate and cluster of infections.

Objectives of the Study

The objectives of the study are

1. To document the rates of surgical site infections stratified by risk index and operative procedure
2. To identify the common causative pathogens
3. To identified the risk factors for surgical site infection

MATERIALS & METHODS

The study prospectively collected data from the patients undergoing certain major operations in Songklanagarind hospital during September 1998 to March 2000.

SETTING

Songklanagarind hospital is a university hospital belonging to Faculty of Medicine, Prince of Songkla University. The hospital is a 650-bed facility serving as a tertiary care, residency training center. The hospital has been also serving as a teaching hospital for medical, nursing and other health care related students.

The infection control unit was established in 1986 with two full-time infection control nurses. The comprehensive nosocomial infection surveillance had been instituted until 1992. In order to meet the criteria of Hospital Accreditation, the infection control committee is planning for the continuous nosocomial infection surveillance including surgical site infection surveillance.

SUBJECTS

The study included the patients of the department of general surgery, neurosurgery, plastic surgery, urosurgery, pediatric surgery, and orthopedic surgery. The patients that were included in the study were the patients that undergoing major operation in the hospital during the study period. The patients that were excluded from the study including the patients with: anal surgery such as hemorrhoidectomy, surgery of oropharynx, skin graft, burn or scald.

DATA COLLECTION

The log book of the operative theatre was reviewed every day for the operation that meet with the inclusion criteria. The name, hospital number, and ward of the patients were identified via the records in the operative log book. Each of the two infection control nurses visited each ward including intensive care unit twice a week. The medical records of the patients, operative notes, anesthesia record, diagnostic imaging report, and the laboratory results including microbiology data were reviewed. After discussion with the nurses in that ward and the attending physicians, the pertinent data were recorded in the preprinted data collection forms. The information recorded including patient's demography, operative procedure, antibiotic used, therapeutic and diagnostic intervention, signs and symptoms related to infection.

DIAGNOSIS OF INFECTION

The criteria put forth by the Center for Disease Control and Prevention [3] were employed for diagnosing nosocomial infection. The surgical site infections were diagnosed by using the CDC definition [4].

CLASSIFICATION OF SURGICAL WOUND

The operative procedures were classified according to degree of contamination into any one of the four classes (clean, clean-contaminated, contaminated, or dirty/infected). The details of wound classification are shown in **Appendix A**. The operative procedure were also categorized by risk index [5] according to the risk of developing postoperative infection.

RESULTS

The study included 4,193 patients undergoing 4,437 major operations in Songklanagarind hospital during September 1998 to March 2000. Among the studied operations, 22.9% were emergency operations. The average hospital stay of the patients was 15.5 days. The average preoperative and postoperative stay was 5.3 and 11.8 days respectively.

There were 506 nosocomial infections identified including 192 surgical site infections, 133 urinary tract infections, 123 lower respiratory tract infections, and 36 bloodstream infections.

PATIENT CHARACTERISTICS

The study included 4,193 patients admitted for surgery in Songklanagarind hospital. The studied patients had average age of 40.4 year with male sex of 54.9% and the average length of hospital stay was 15.5 days. The mortality rate of the studied patients was 1.7%.

SURGICAL OPERATION

The study included 4,437 operations underwent in Songklanagarind hospital. Among these operations, 22.9% were emergency surgery. The average length of hospital stay of the patient prior to surgery was 4.6 days (S.D = 8.5) and the average postoperative stay was 11.8 days. The average duration of operation was 125.5 minutes (S.D = 98.8). The ASA classification of the patients underwent the operations were listed in **Table** 2.

Table 2. ASA classification of the patients underwent operations

ASA classification	Number of operation	Percentage
1. Normally healthy patient	1,725	38.9%
2. Patient with mild systemic disease	2,182	49.2%
3. Patient with severe systemic disease that is not capacitating	465	10.5%
4. Patient with incapacitating systemic disease that is a constant treat to life	61	1.4%
5. Moribund patient who is not supposed to survive for 24 hours with or without operation	4	0.1%
Total	**4,437**	**100.0%**

SURGICAL ANTIBIOTIC PROPHYLAXIS

Antibiotic prophylaxis were administered in 3,857 operations (86.9%). The common antibiotics used in prophylaxis are listed in **Table 3**. Among 3,857 operations with antibiotic prophylaxis, 2,784 operations were administered antibiotic pre-operatively, 810 operations were intra-operative, and 258 operations were post-operative. The most common combination of antibiotic prophylaxis are demonstrated in **Table 4**. The mean duration of antibiotic prophylaxis was 3.0 day (S.D = 3.4). The duration of antibiotic prophylaxis are illustrated in details in **Table 5**.

Table 3. The most common surgical prophylaxis antibiotics administered in 4,437 operations

Prophylaxis antibiotics	Number of operation	Percentage
Cloxacillin	1,464	33.0%
Cefazolin	1,271	28.6%
Gentamicin	980	22.1%
Metronidazole	653	14.7%
Ampicillin	264	5.9%
Cefoxitin	255	5.7%
Cefotaxime	89	2.0%

Note: Percentage = Number of operations with certain antibiotic prophylaxis per 100 operations done

Table 4. The surgical prophylaxis antibiotic combinations

Antibiotic combinations	Number of operations	Percentage
Gentamicin + Metronidazole	393	8.9%
Gentamicin + Cloxacillin	240	5.4%
Gentamicin + Ampicillin	97	2.2%
Cloxacillin + Cefotaxime	38	0.9%
Gentamicin + Metronidazole + Cloxacillin	30	0.7%
Ampicillin + Metronidazole	30	0.7%
Gentamicin + Norfloxacin	25	0.6%

Note: Percentage = Number of operations with certain combination of antibiotics per 100 operations done

Table 5. Duration of antibiotics prophylaxis

Duration of antibiotic prophylaxis	Number of operation	Percentage
Single dose	195	4.4%
More than one dose but not more than one day	1,790	40.3%
2 - 3 days	494	11.1%
4 - 7 days	902	20.3%
>7 days	476	10.7%
Total	3,857	86.9%

Note: Percentage = Number of operations with certain duration of antibiotics per 100 operations done

Urinary Tract Infection

There were 133 episodes of hospital acquired urinary infection identified during the 19-month study period, accounting for 26.3% of all nosocomial infection. Among these 133 urinary tract infection, there were 106 symptomatic urinary tract infections and 27 asymptomatic bacteriuria detected. The five most common causative pathogens responsible for urinary tract infection were demonstrated in **Table 6**.

Table 6. The most common isolated pathogens of urinary tract infection

Pathogens	Number of isolation	Percentage
Escherichia coli	48	36.1%
Klebsiella pneumoniae	25	18.8%
Enterococci	16	12.0%
Pseudomonas aeruginosa	14	10.5%
Acinetobacter baumannii	10	7.5%

Note: Percentage = Number of isolation per 100 infection episodes.

LOWER RESPIRATORY TRACT INFECTION

Over the study period, we recorded 61 episodes of hospital acquired pneumonia, accounting for 12.1% of all nosocomial infections, in 60 patients. Sixty one patients with endotracheal intubation experienced 62 episodes of tracheobronchitis. The causative pathogens responsible for pneumonia obtained from uncontaminated specimens (blood culture, aspirated plural fluid, broncho-alveolar lavage) were as follow: *Pseudomonas aeruginosa, Acinetobacter baumannii, Escherichia coli, Klebsiella pneumoniae, and Staphylococcus aureus* which accounting for 4, 2, 2, 1, and 1 isolation respectively. The identified pathogens of tracheobronchitis are displayed in **Table 7.**

Table 7. The common pathogens responsible for tracheobronchitis

Pathogens	Number	Percentage
Klebsiella pneumoniae	24	38.7%
Acinetobacter baumannii	21	33.9%
Pseudomonas aeruginosa	20	32.3%
Staphylococcus aureus	7	11.3%
Proteus mirabilis	3	4.8%
Enterobacter cloacae	3	4.8%
Escherichia coli	2	3.2%

Note: Percentage = Number of isolation per 100 infection episodes.

BLOODSTREAM INFECTION

There were 36 episodes of nosocomial primary bloodstream infections identified in the surgical patients. Fifteen patients experienced 16 episodes of laboratory confirmed hospital acquired bacteremia. Twenty patients developed clinical septicemia during hospitalization. The isolated pathogens of 16 episodes of bloodstream infections are illustrated in **Table 8.**

Table 8. The common pathogens responsible for primary bloodstream infections.

Pathogens	Number	Percentage
Acinetobacter baumannii	4	11.1%
Escherichia coli	4	11.1%
Staphylococcus aureus	4	11.1%
Klebsiella pneumoniae	1	2.8%
Proteus mirabilis	1	2.8%
Serratia marcescens	1	2.8%
Yeast	1	2.8%

Note: Percentage = Number of isolation per 100 infection episodes.

OTHER INFECTIONS

During hospitalization, there were 8, 2, 2, 2, 1, 1, 1, and 1 episode of sinusitis, phlebitis, primary peritonitis, septic arthritis, dental root abscess, meningitis, bedsore infection, and onychitis developed in the studied patients.

SURGICAL SITE INFECTION

There were 192 surgical site infections detected in 4,436 operations, yielding the infection rate of 4.3 infections per 100 operations. The surgical site infections accounted for 37.9% of all hospital acquired infections. Among these 192 surgical site infections, there were 98 superficial surgical site infections; 38 deep surgical site infections; and 56 organ/space infections. The infection rates according to degree of wound contamination are illustrated in **Table 9**. The surgical site infection according to modes of administration of antibiotic prophylaxis are illustrated in **Table 10**. The surgical site infection stratified by ASA class of patients are demonstrated in **Table 11**. The common causative pathogens identified from infected sites are listed in **Table 12.** The surgical site infection rates according to common operative procedure and NNIS risk index are shown in **Table 13** together with infection rates reported from the other institutes. No surgical site infection detected in overall 114 laparoscopic cholecystectomy performed in Songklanagarind hospital during the studied period.

Table 9. Surgical site infection stratified by degree of contamination

Wound Class	No. of operation	No. of infection	Infection rate
Clean	3,087	72	2.3%
Clean-contaminated	939	45	4.8%
Contaminated	288	43	14.9%
Dirty/Infected	123	32	26.0%
Total	**4,437**	**192**	**4.3%**

Note: Infection rate = Number of infection per 100 operations

Table 10. Surgical site infection stratified by modes of antibiotic prophylaxis administered

Antibiotic prophylaxis	No. of operation	No. of infection	Infection rate
Preoperative	2,784	131	4.7%
Intraoperative	810	30	3.7%
Postoperative	258	12	4.7%
No antibiotic prophylaxis	585	19	3.2%
Total	**4,437**	**192**	**4.3%**

Note: Infection rate = Number of infection per 100 operations

Table 11. Surgical site infection stratified by ASA classification

ASA Class	No. of operation	Infection	Infection rate
1. Normally healthy patient	1725	33	1.9%
2. Patient with mild systemic disease	2182	103	4.7%
3. Patient with severe systemic disease that is not capacitating	465	47	10.1%
4. Patient with incapacitating systemic disease that is a constant treat to life	61	8	13.1%
5. Moribund patient who is not supposed to survive for 24 hours with or without operation	4	1	25.0%

Note: Infection rate = Number of infection per 100 operations

Table 12. The most common isolated pathogens of surgical site infection

Pathogens	Number	Percentage
Staphylococcus aureus	54	28.1%
Escherichia coli	32	16.7%
Pseudomonas aeruginosa	23	12.0%
Klebsiella pneumoniae	17	8.9%
Enterococci	16	8.3%

Note: Percentage = Number of isolation per 100 infected sites

Table 13. Procedure specific surgical site infection rates of the common operative procedure comparing with reports from NNIS and Hungary.

Procedure	Report	RI	N	Rate	RI	N	Rate	RI	N	Rate
Herniorrhaphy	PSU	0	150	4.7	1	27	-	2,3	4	-
	NNIS	0	7,251	0.8	1	3,982	1.9	2,3	901	3.4
	Hungary	0	NA	1.4	1	NA	2.1	2,3	NA	9.1
Mastectomy	PSU	0,1	159	3.1	2,3	-				
	NNIS	0,1	11,178	2.1	2,3	403	4.0			
	Hungary	0,1	NA	9.2	2,3	NA	16.7			
Craniotomy	PSU	0	99	1.0	1,2,3	215	7.9			
	NNIS	0	2,054	0.6	1,2,3	8,112	1.8			
Appendectomy	PSU	0-No	154	0.6	1	145	2.1	2,3	63	12.7
	NISS	0-No	3,866	1.4	1	4,957	3.2	2,3	2,121	5.9
	Hungary	0	NA	1.3	1	NA	3.9	2,3	NA	6.3
Cholecystectomy	PSU	-1	94	-	0	73	1.4	1	81	9.9
	NISS	-1	17,095	0.5	0	15,471	0.7	1	7,417	2.0
	Hungary				0	NA	0.5	1	NA	1.2
	PSU	2	26	15.4	3	3	33.3			
	NISS	2	2,492	3.5	3	318	6.6			
	Hungary	2	NA	5.1	3	NA	12.5			

Note: PSU = Songklanagarind hospital
NNIS = National Nosocomial Infections Surveillance (Jan 1990 – May 1999)
Hungary = Hungarian Society for Quality Assurance in Health Care (1996)
RI = -1; When the patient in risk category 0 undergoing laparoscopic cholecystectomy
0-No ; When the patient in risk category 0 undergoing laparotomy appendectomy
NA = Number of operation is not available from the report

RISK FACTORS FOR SURGICAL SITE INFECTION

To identified the risk factor for developing surgical site infection, the association between surgical site infection and the following factors including age, sex, type of surgery (elective or emergency surgery), preoperative length of hospital stay, duration of administering antibiotic prophylaxis, duration of operation, ASA class of the patient at the time of surgery, degree of wound contamination, and mode of administering antibiotic prophylaxis were evaluated first by univariated analysis. The strength association was reported in term of odds ratio. The role of chance was evaluated in term of 95% confidence interval (95%C.I). The odds ratio together with 95% C.I were shown in **Table 14**. To control for the effect of confounding factors, the factors that showed statistical significance resulting from univariated analysis were included in the multivariate analysis. The multivariate analysis was done by mean of multiple logistic regression models. The results of multivariate analysis were displayed in **Table 15**.

Table 14. Univariated analysis for the association between various factors and surgical site infection

Variables	Odds ratio	95%C.I
Age (1 year increment)	1.002	0.997 – 1.007
Male sex	1.384	1.026 – 1.867
Emergency surgery	2.145	1.588 – 2.896
Preoperative hospital stay (1 day increment)	1.023	1.012 – 1.033
Duration of antibiotic prophylaxis (1 day increment)	1.138	1.102 – 1.176
Duration of operation (1 minute increment)	1.003	1.002 – 1.004
ASA class		
I	1	Reference
II	2.540	1.707 – 3.779
III	5.765	3.647 – 9.112
IV	7.739	3.410 – 17.56
V	17.090	1.732 – 168.6
Degree of wound contamination		
Clean	1	Reference
Clean-contamination	2.107	1.441 – 3.081
Contamination	7.349	4.928 – 10.95
Dirty/Infected	14.725	9.242 – 23.45
Antibiotic prophylaxis administration		
Pre-operative	1	Reference
Intra-operative	0.778	0.519 – 1.167
Post-operative	0.987	0.539 – 1.809
No antibiotic prophylaxis	0.679	0.416 – 1.109

Table 15. Multivariate analysis for the association between various factors and surgical site infection

Variables	Odds ratio	95%C.I
Male sex	1.182	0.862 – 1.620
Emergency surgery	1.382	0.986 – 1.938
Pre-operative hospital stay (1 day increment)	1.005	0.993 – 1.016
Duration of antibiotic prophylaxis (1 day increment)	1.032	0.995 – 1.071
Duration of operation (1 minute increment)	1.003	1.002 – 1.004
ASA class		
I	1	Reference
II	2.000	1.324 – 3.021
III	3.445	2.108 – 5.631
IV	4.404	1.785 – 10.86
V	5.908	0.472 – 73.88
Degree of wound contamination		
Clean	1	Reference
Clean-contamination	2.059	1.382 – 3.069
Contamination	5.432	3.560 – 8.289
Dirty/Infected	9.391	5.458 – 16.15

DISCUSION

Despite advances in operative techniques, better understanding of the epidemiology of wound infection, and widespread use of prophylactic antibiotics, postoperative infections continue to be a major source of morbidity and mortality for patients undergoing operative procedures. It is estimated that surgical site infections develop in 2-5% of the million patients undergoing surgical procedures each year [6,7]. They account for about 24% of all nosocomial infections, making surgical site infection the second most common site of nosocomial infections in general hospitalized population [8].

This study was a prospective study with primary intention to establish the infection complication in surgical patients. The merit of prospective study is that the completeness of the information needed can be ensured. In the study on surgical site infection, the information about sign and symptom of infection are crucial in making diagnosis of infection.

The studied patients were relatively severe compared to general patients. Because Songklanagarind is the referral center for the southern part of Thailand. The results of this study show that the age of patients was about 40 years in average and the ASA class II was the most common severity class (**Table 2**).

The most common prophylactic antibiotic identified by this study was cloxacillin (33.0%) followed by cefazolin (28.6%) (**Table 3**). The commonest combination of antibiotic used for prophylaxis was the combination between gentamicin and metronidazole (**Table 4**).

The results of the study showed that the most common site of infection in surgical patient was surgical site infection which accounted for 37.9% of all hospital acquired infections followed by urinary tract infection which accounted for 26.3% of all nosocomial infections.

The most common pathogens responsible for pneumonia, tracheobronchitis, primary bloodstream infection were *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Acinetobacter baumannii* respectively (**Table 6-8**). The most common pathogen of surgical site infection identified by this study was *Staphylococcus aureus* (Table 12). This result of the study is consistent with the past experience that *Staphylococcus aureus* has long been identified as the most common causative agent responsible for the surgical infection [9].

The results of the study indicate that surgical site infection increase as the degree of contamination or ASA class increase.

Intuitively, host susceptibility, that is, the host's intrinsic ability to defend itself against microbial invasion, should be an important determinant of the risk of infection following surgery. over the years studies have examined many host factors as to whether or not they affected the surgical site infection rate, including such factors as age, obesity, nutritional status, and the presence of certain underlying disease such as diabetes and malignancy. These factors were used, in effect, as surrogate markers for the host's intrinsic susceptibility to infection.

Of the host factors, advance age has consistently been found to be a risk factor for the host's intrinsic susceptibility to infection [10-12]. But this study could not demonstrate age as the statistical significant risk factor (**Table 14**). The lack of association might have been due to the inclusion of another marker into the regression model, the ASA physical status, that was better predictor of host susceptibility than age alone. Garibaldi and colleagues [13] also included ASA class into the multiple regression analysis and found that age showed no significant association with surgical site infection.

The statistical significant association between male sex and surgical site infection identified from univariated analysis may due to the effect of extraneous variables such as severity of trauma. This hypothesis was supported by the multivariate analysis that found no significant association when control for the confounding factors.

Over the years, early studies have consistently demonstrated the adverse effect of prolonged preoperative stay on the rate of surgical site infections. The National Research Council study found that the rate of surgical site infection rose from 6% for a preoperative day of 1 day to 14.7% when the preoperative stay was 21 or more days [14]. Cruse and Foord reported that the overall infection rate was 1.1% for patients whose preoperative stay was 1 day versus 2.1% in patients who remained in the hospital for 1 week before their operation [15]. These early studies might be criticized, because the influence of other risk factors was not specifically taken into account. The results of the analysis of this study have shown that the statistically significant association between length of preoperative stay (**Table 14**) was diminished after controlling for confounding effect of other risk factors by mean of multivariate analysis (**Table 15**). However, these phenomenon may due to the insufficient number of studied samples. Because more recent studies [13,16-18] that have also used multivariate analysis methodology to adjust for potentially confounding variables continued to find prolong preoperative stay to be an important risk factor for surgical site infection.

The mechanism by which prolonged hospital stay brings about an increased risk of infection is unknown. A long preoperative stay may promote proliferation of endogenous microorganisms, which can then more heavily contaminate the operative wound, or such a stay may promote the acquisition of hospital-acquired multidrug resistant pathogens. Prolong preoperative stay also permits the performance of procedural interventions that allow microorganism access into the body or chemotherapeutic interventions that can adversely effect the host resistance. or alter normal flora. Some researcher have found that patients who are hospitalized for cardiovascular surgery quickly become colonized with methicillin-resistant coagulase-negative staphylococci and that these organisms were responsible for surgical site complications including mediastinitis and prosthetic valve endocarditis [19-21].

The length of surgical operation has long been established as an important risk factor for surgical site infection. The CDC's Study on the Efficacy of Nosocomial Infection Control found that having an operation lasting more than 2 hours was one of the four risk factors for surgical site infection that remained significant when logistic regression techniques were applied to SENIC database [22]. This study also found that the duration of operative time was a statistically significant independent risk factor. For each minute prolong in operative time the odds of infection increase by 0.3%.

Exactly how lengthening duration of operation increases the risk for surgical site infection remains speculative. Cruse and Foord [15] listed four postulate explanations: (*a*) an increase in the contamination of the wound with longer operations, (*b*) an increase in tissue damage from drying, prolong retraction, and manipulations, (*c*) an increase in the amount of suture and electrocoagulation, which may reduce the local resistance of the wound, and (*d*) greater suppression of host defenses from blood loss and shock. Garibaldi and coworkers [13] added that the duration of surgery may be a marker for factors that are difficult to corporate in multivariate modeling such as the skill of the surgeon and complexity of surgery. Shapiro and colleagues suggested that increased infections after prolonged hysterectomy may due to the result of decreasing effect of antibiotic prophylaxis with lengthy procedures [23].

Shortly after Word War II, the efficacy of systemic antimicrobial drugs for preventing infections in elective operations was explored by a number of investigators, with contradictory findings. This was primarily due to variations in timing of administration of drugs in relation to the time of operation in the different studies. Burke [24], in precise animal studies, defined the narrow time period after surgical incision during which prophylactic antibiotics may prevent infection. This concept led to several well-conducted studies, including those of Bernard and Cole [25] and Polk and Lopez-Major [26], which provided unequivocal evidence of effectiveness of preoperative antibiotic prophylaxis in preventing infections after elective clean-contaminated operations. By contrast, antibiotics administered only postoperatively have no prophylactic effect. But this study could not find any evidence that suggest the preventive effect of prophylactic antibiotic. This result might have been due to lack of sample size in high-risk patients without antibiotic prophylaxis. In contrast, this study found the adverse effect of prolonged use of antibiotic prophylaxis. The explanation of this finding may be the reduction in normal host flora attributable to antibiotic pressure.

The surgical site infection rate of laparoscopic cholecystectomy performed in Songklanagarind hospital during the studied period compare to the other institutes are demonstrated in **Table 16**.

Table 16. Surgical site infection after laparoscopic cholecystectomy

Authors	N	Rates	References
PSU	114	0.0	This study
Garcia, et al.	225	1.8	[27]
den Hoed, et al.	189	5.3	[28]
McGuckin, et al.	1,702	2.3	[29]

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APPENDIX A

SURGICAL WOUND CLASSIFICATION

The risk of developing a postoperative surgical site infection is affected by the degree of microbial contamination of the operative site. A widely accepted system of classification by the degree of contamination was developed by the National Research Council for its cooperative study of the effect of ultraviolet irradiation of operating rooms on surgical site infection. This classification scheme, in a modified form, is presented below:

Clean: An uninfected operative wound in which no inflammation is encountered and the respiratory, alimentary, genital, or uninfected urinary tract is not entered. In addition, clean wound are primary closed and if necessary, drained with closed drainage. Operative incisional wounds that follow nonpenetrating (blunt trauma) should be included in this category if they meet the criteria

Clean-contaminated: An operative wound in which the respiratory, alimentary, genital, or urinary tract are entered under controlled conditions and without unusual contamination. Specifically, operation involving the biliary tract, appendix, vagina, and oropharynx are included in this category, provided no evidence of infection or major break in technique is encountered.

Contaminated: Opened, fresh, accidental wounds. In addition, operations with major breaks in sterile technique (e.g., open cardiac massage) or gross spillage from the gastrointestinal tract, and incisions in which acute, non purulent inflammation is encountered are included in this category.

Dirty-Infected: Old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera. This definition suggests that the organisms causing postoperative infection were present in the operative field before the operation.

APPENDIX B

CRITERIA FOR DIAGNOSING A SURGICAL SITE INFECTION

The identification of surgical site infection involves interpretation of clinical and laboratory findings, and it is crucial that a surveillance program use definitions that are consistent and standardized; otherwise, inaccurate or uninterpretable SSI rates will be computed and reported. The CDC's NNIS system has developed standardized surveillance criteria for defining SSIs. By these criteria, surgical site infections are classified as being either incisional or organ/space. Incisional surgical site infection s are further divided into those involving only skin and subcutaneous tissue (superficial incisional surgical site infection) and those involving deeper soft tissues of the incisional (deep incisional surgical site infection). Organ/space surgical site infection involve any part of the anatomy (e.g., organ or space) other than incised body wall layers, that was opened or manipulated during an operation.

Criteria for definining a surgical site infection

Superficial incisional surgical site infection

Infection occurs within 30 days after the operation *and* infection involves only skin or subcutaneous tissue of the incision *and* at least *one* of the following

1. Purulent drainage, with or without laboratory confirm, from the superficial incision.
2. Organisms isolated from an aseptically obtained culture or fluid or tissue from the superficial incision.
3. At least one of the following signs or symptoms of infection: pain or tenderness, localized swelling, redness. or heat *and* superficial incision is deliberately opened by surgeon, *unless* incision is culture-negative
4. Diagnosis of superficial incision surgical site infection by the surgeon or attending physician

Do not report the following conditions as surgical site infection

1. Stitch abscess (minimal inflamation and discharge confined to the points of suture penetration)
2. Infection of an episiotomy or newborn circumcision site
3. Infected burn wound
4. Incisional surgical site infection that extends into and muscle layers (see, deep incisional surgical site infection)

Note : Specific criteria are used for identifying infected episiotomy and circumcision sites and burn wounds.

Deep incisional surgical site infection

Infection occurs within 30 days after the operation if no implant is left in place or within 1 year if implant is in place and the infection appears to be related to the operation *and* infection involves deep soft tissues (e.g., fascial and muscle layers) of the incision *and* at least *one* of the following:

1. Purulent drainage from the deep incision but not from the organ/space component of the surgical site
2. A deep incision spontaneously dehisces or is deliberately opened by a surgeon when the patient has at least one of the following signs or symptoms: fever (more than 38°C), localized pain, or tenderness, unless site is culture-negative
3. An abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiologic examination.
4. Diagnosis of a deep incisional surgical site infection by a surgeon or attending physician

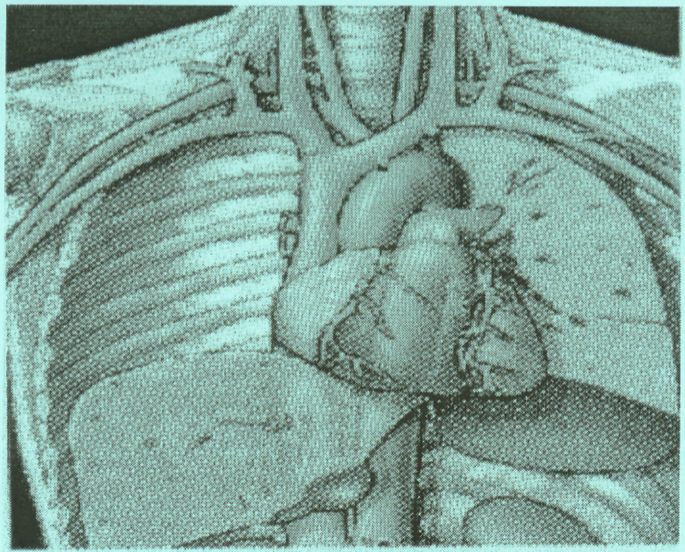
Note :

1. Report infection that involves both superficial and deep incision site as deep incisional surgical site infection
2. Report an organism/space surgical site infection that drains through the incision as a deep incisional surgical site infection

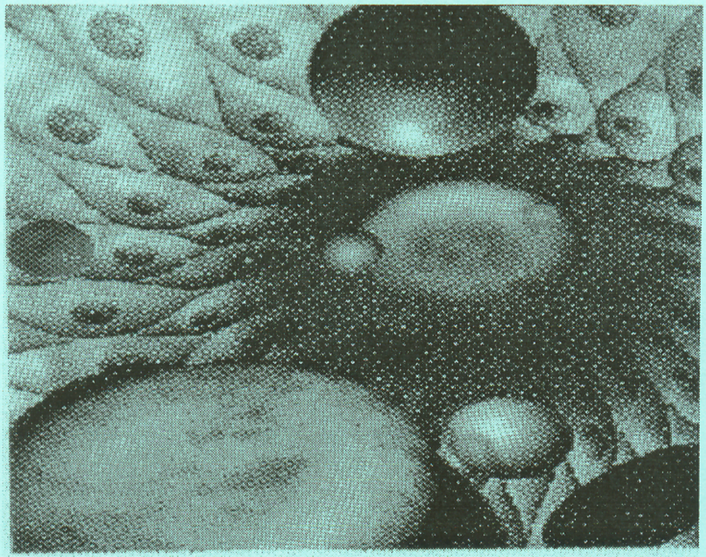
Organ/space surgical site infection

Infection occurs within 30 days after the operation if no implant is left in place or within 1 year if implant is in place and the infection appears to be related to the operation *and* infection involves any part of anatomy (e.g., organs or spaces), other than the incision, which was opened or manipulated during an operation *and* at least *one* of the following:

1. Purulent drainage from a drain that is placed though a stab wound into the organ/space (If the area around a stab wound becomes infected. it is not an surgical site infection)
2. Organism isolated from an aseptically obtained culture of fluid or tissue in the organ/space
3. An abscess or other evidence of infection involving the organ/space that is found on direct examination, during reoperation, or by histopathologic or radiologic examination
4. Diagnosis of an organ/space surgical site infection by a surgeon or attending physician



CARDIOVASCULAR SYSTEM



FLUID, ELECTROLYTE, AND ACID/BASE BALANCE