Device-Associated Infections and Patterns of Antimicrobial Resistance in a Medical-Surgical Intensive Care Unit in a University Hospital in Thailand

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Background : *Surveillance of nosocomial infection in the intensive care unit (ICU) received a high level of attention and outcome indicators are now used in benchmarking the quality of patient care. Since 1999 the surveillance has targeted three site-specific, device-associated infections, including ventilator-associated pneumonia (VAP), central-line-related bloodstream infection (CR-BSI), and catheter-related urinary tract infection (CR-UTI). The authors conducted a two-year prospective study on the incidences of these infections acquired in an ICU and report herein, together with the antibiotic susceptibility patterns of the microorganisms isolated in an ICU.*

Patients and Method : *Continuous prospective data collection was conducted on patients admitted to an adult medical-surgical ICU of a university hospital in Thailand from June 2000 to May 2002.*

Results : *A total 1422 patients with a total of 9370 patient-days were enrolled in the study. The incidence of VAP, CR-BSI, and CR-UTI were 10.8/1000 ventilator-days (95%C.I: 8.5-13.6), 2.6/1000 central-line-days (95%C.I: 1.5-4.4), and 13.8/1000 urinary-catheter-days (95%C.I: 10.7-17.5) respectively. The most common causative pathogens were Escherichia coli, Acinetobacter baumannii, Pseudomonas aeruginosa, and Klebsiella pneumoniae. The proportion of methicillin-resistant Staphylococcus aureus, imipenem-resistant P. aeruginosa, ceftazidime-resistant A. baumannii, third-generation-cephalosporin-resistant K. pneumoniae, and quinolone-resistant E. coli were 68.8%, 30.9%, 68.5%, 44.6%, 38.3% respectively.*

Conclusion : *The incidences of VAP and CR-BSI were comparable to the National Nosocomial Infection Surveillance (NNIS) report. But the incidence of CR-UTI was over the 90th percentile. The antibiotic resistance had become a serious problem.*

Keywords : *Intensive care unit, Cross infection, Device-associated infection, Antimicrobial resistance*

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Specialized high-technology units for caring for critically ill patients have become an integral part of modern medicine. The advance in life-support systems permits longer survival of seriously ill patients. This creates a new kind of patient population with long indwelling invasive diagnostic and therapeutic devices, often with extremely severe diseases, and compromised host defense mechanisms. Hence, it comes as no surprise to find that the incidence of nosocomial infection acquired in the intensive care unit (ICU) is two to five times higher than that in an ordinary ward[1]. Furthermore, the mortality rate of hospital acquired infection in the ICU was 16 to 44%[2,3].

The ICU also presents an environment in which circumstances conspire to accelerate the

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evolution of antimicrobial resistance through the frequent and prolonged use of antibiotics[4,5]. In addition to antimicrobial pressure, the patients admitted to an ICU are exposed to a greater hazard of contamination and cross-infection than those in other wards. This is due to the fact that they receive many more nursing procedures, and various forms of instrumentation.

Surveillance of nosocomial infections in ICUs has received high level of attention and the outcome indicators are now used in benchmarking the quality of patient care. Since January 1999, the National Nosocomial Infections Surveillance (NNIS) system of the Division of Healthcare Quality Promotion of Centers for Disease Control and Prevention (CDC) has abandoned the hospital-wide surveillance program, and has fococused focusing on the infections acquired in ICU, high-risk nursery, and surgical patients[6].

Effective control measures require a sound knowledge in epidemiology of nosocomial infections in an ICU. Benchmarking may be used to monitor their evolution and to detect any unusual variations that may indicate an outbreak or high endemic infection rates. The authors conducted a continuous surveillance of hospital-acquired infections in a medical-surgical ICU in a university hospital in Thailand to elucidate the patterns of infections and antimicrobial resistance.

Patients and Method

Setting

Songklanagarind Hospital is a university hospital of the Faculty of Medicine, Prince of Songkla University. The hospital is a 750-bed facility serving as a medical school, residency training, and regional referral center in the southern part of Thailand. The hospital has three ICUs, consisting of a 14-bed adult medical-surgical ICU, a 6-bed pediatric ICU, and a 10-bed neonatal ICU. The hospital also has special care units such as a 16-bed respiratory care unit and a 10-bed high risk nursery. The medical-surgical ICU has a patient to nurse ratio of 2:1, with a bed utilization rate of 90.3%. There was no standardized system devised for routinely assessing severity of illness of patients admitted to the ICU.

Data collection

The nosocomial infection surveillance program in the ICU was conducted by one of three infection control nurses (ICNs). The surveillance included all patients admitted to the ICU from June 1, 2000 to May 31, 2002. The nurses in charge in the ICU daily recorded data concerning device indwelling in a preprinted form. The ICN visited the ICU three times a week to record pertinent data on the standardized data collection forms. Demographic data of the patients including age, sex, diagnosis and operation were recorded. Medical interventions such as antimicrobial administration, stress ulcer prophylaxis and invasive procedures were recorded. Clinical signs and symptoms associated with infection were noted. Laboratory results including white blood count, microbiology investigation, serology, imaging reports including chest x-ray, ultrasonogram, computerized tomogram, and magnetic resonant imaging were reviewed. Antimicrobial susceptibility was identified by using the Kirby-Bauer disk diffusion method. All patients were followed from the first day of admission to the ICU until discharge. After hospital discharge the medical records of the patients were reviewed for any missing information. There was no post-discharge surveillance of NI. The diagnosis of infections was made after completion of the data collection form and discussion with a hospital epidemiologist using CDC NNIS definitions and criteria[7,8].

Analysis

Data were entered and processed on a microcomputer using Microsoft Visual Fox Pro 6.0 (Microsoft Corporation, WA). Patient-days were defined as the total days of ICU stay. Device-days were defined as the total days in the ICU that the device was in place. Device utilization (DU) ratio was defined as the ratio of number of device-days to number of patient-days. The derived DU ratios, incidences of infections, and proportions of antimicrobial resistant microorganisms were compared to the NNIS percentiles of distribution.

Incidence rates of infections were calculated both in terms of cumulative incidence and incidence density. Cumulative incidence was defined as the number of device-associated infections per 100 patients with that specific device. Incidence density was defined as the number of device-associated infections per 1000 device-days. Confidence interval of DU ratio, cumulative incidence, and incidence density were computed by binomial and Poisson exact statistics using STATA version 7 statistical software (STATA Corporation, College Station, TX). The device-associated infection rates were

Table 1. The incidence rates of device-associated infections and the corresponding 95% C.I (in parentheses)

Numbers and rates	VAP	CR-BSI	CR-UTI
Patients with devices	1076	893	1196
Device-days	6850	5667	4790
Device-associated infections	74	15	66
Device utilization ratio	0.73 (0.72-0.74)	0.60 (0.59-0.61)	0.51 (0.50-0.52)
NNIS percentile*	> 90	50-75	< 10
Cumulative incidence	6.9 (5.4-8.6)	1.7 (0.9-2.7)	5.5 (4.3-7.0)
Incidence density	10.8 (8.5-13.6)	2.6 (1.5-4.4)	13.8 (10.7-17.5)
NNIS percentile*	50-75	10-25	> 90

* Percentile distribution of medical-surgical ICUs of major teaching hospital

compared to the published reports from various countries.

Results

Patient characteristics

A total of 1422 patients were included involving 1469 hospital admissions, 1612 ICU admissions and 9370 patient-days in the ICU. The mean patient age was 57.6 years (S.D 17.8) and the ICU mortality was 20.0 per 100 ICU admissions. The median length of ICU stay was 3 days (interquartile range 2 to 6).

Nosocomial infection

The study detected 204 infections acquired in the ICU during the study period. There were 155 device-associated infections yielding an incidence density of ventilator-associated pneumonia (VAP), central-line-related bloodstream infection (CR-BSI), and catheter-related urinary tract infection (CR-UTI) of 10.8/1000 ventilator-days, 2.6/1000 central-line-days, and 13.8/1000 urinary-catheter-days respectively. The DU ratios and incidences of device-associated infections together with the corresponding NNIS percentiles are shown in Table 1. The study could identify 107 pathogens responsible for device-associated infections including 75 (70.1%) gram-negative bacteria, 13 (12.1%) gram-positive bacteria, 18 (16.8%) fungi, and 1 (0.9%) virus. The common pathogens isolated from specific sites of infections are listed in Table 2. A comparison between reports from various countries is shown in Table 3.

Table 2. Most frequently isolated pathogens according to the sites of infections

Pathogens	VAP	CR-BSI	CR-UTI	Total
Escherichia coli	1	1	14	16
Acinetobacter baumannii	5	3	7	15
Pseudomonas aeruginosa	4	-	8	12
Enterobacter cloacae	1	-	10	11
Klebsiella pneumoniae	2	-	8	10
Staphylococcus aureus	1	6	-	7

Table 3. Device-associated infection rates from various medical/surgical ICUs

Authors	Country	Site specific incidence density		
		VAP	CR-BSI	CR-UTI
CDC (major teaching hospital) [9]	USA	10.5	5.3	5.8
Cook, et al[10,11]	Canada	14.8	NA	NA
Gastmeier, et al[12]	Germany	9.1	1.1	1.6
Legras, et al[13]	France	9.4	3.8	8.5
Pallavicini, et al[14]	Italy	2.9-6.3	6.5-9.3	2.6-4.6
Khuri-Bulos, et al[15]	Jordan	19.1	3.0	15.6
Finkelstein, et al[16]	Israel	20.4	12.5	13.6
Yoo, et al[17]	Korea	NA	1.3-4.2	NA
This study	Thailand	10.8	2.6	13.8

NA = No data available

Table 4. Antimicrobial resistance rates and percentiles of distribution according to NNIS report

Antimicrobial resistant bacteria	Isolates	Resistant	Percentage	NNIS Percentile
Methicillin-resistant *S. aureus*	263	181	68.8	> 90
Methicillin-resistant Coagulase-negative staphylococcus	119	52	43.7	< 10
Vancomycin-resistant *enterococcus* spp	213	-	-	10
Ciprofloxacin/ofloxacin-resistant *P. aeruginosa*	501	197	39.3	50-75
Imipenem-resistant *P. aeruginosa*	501	155	30.9	75-90
Ceftazidime-resistant *P. aeruginosa*	501	262	52.3	> 90
Ciprofloxacin/ofloxacin-resistant *A. baumannii*	422	227	53.8	NA
Ceftazidime-resistant *A. baumannii*	422	289	68.5	NA
Ciprofloxacin/ofloxacin-resistant *K. pneumoniae*	271	28	10.3	NA
Ceftazidime-resistant *K. pneumoniae*	271	120	44.3	NA
Cef3-resistant *K. pneumoniae*	271	121	44.6	> 90
Cef3-resistant *Enterobacter* spp.	165	118	71.5	> 90
Cef3-resistant *E. coli*	193	31	16.1	> 90
Carbapenem-resistant *Enterobacter* spp.	165	3	1.8	< 90
Quinolone-resistant *E. coli*	193	74	38.3	> 90
Penicillin-resistant *S. pneumoniae*	17	11	64.7	> 90
Cefotaxime/ceftriaxone-resistant *S. pneumoniae*	17	-	-	10

NA = No data available for comparison

Antimicrobial resistance

There were 3066 isolates of microorganisms from patients admitted to the ICU during the study period. The patterns of antimicrobial resistance are demonstrated in Table 4.

Discussion

During the past decade, there has been increasing interest in measuring and improving the quality of health care in many countries. In Thailand, health care reform requires that the hospitals in the country develop quality management programs. In conducting quality improvement programs, benchmarking is one of the basic elements which must be considered. The published ICU-acquired infection rates in the hospitals in Thailand are rarely available and usually are not the risk-adjusted rates. The NNIS reported data make it possible for hospitals to benchmark infection-complication outcomes.

The results of the present study revealed that nosocomial infection acquired in the ICU was common, occurring at a rate about 15% of admitted patients. Device-associated infections comprised about three-quarters. The present results are consistent with others, in that VAP was the most common device-associated infection. While many other studies reported the incidence of VAP to be the highest, the present study found CR-UTI had the highest infection rate (Table 3). The explanation for this phenomenon may be the lapse of infection control practices in this field. A high incidence of CR-UTI in other wards led to a brief investigation, covering 211 patients with 762 urinary-catheter-days, and discovered poor compliance with hospital recommendations (*Jamulitrat S* unpublished data).

E. coli was the most common pathogen in device-associated infections (Table 2), and CR-UTI was the most common site from which *E. coli* were isolated. The pathogens of VAP were identified with relatively less frequency, because a true VAP pathogen has to be identified from uncontaminated specimens such as hemoculture, pleural fluid, brochoaveolar lavage, lung biopsy, and lung aspiration, these investigations were not routinely done in patients with a diagnosis of pneumonia except for hemoculture.

Each ICU develops its own group of resistant strains. In the present study the greatest problems attributable to antibiotic-resistant microorganisms were from methicillin-resistant *S. aureus* (MRSA) and multi-resistant *A. baumannii*. The outbreak of MRSA in Songklanagarind Hospital began in late 1989 and has been an endemic nosocomial pathogen in the hospital ever since[18]. The percentage of MRSA to the total *S. aureus* isolated in Thailand in the year 2001 was 47% for ICUs, 30% for inpatients, and 12% for outpatients[19]. The high proportion of MRSA in our ICU may be

from the repeated cultures. Due to the guidelines for control multiresistant microorganisms in our hospital, the patient in whom multiresistant bacteria was isolated must be put into contact isolation and monitored by culture until three consecutive culture negatives. There was no data concerning multi-resistant *A. baumannii* in the NNIS report, although, this pathogen has created problems in many institutes[20,21]. Imipenem-resistant *P. aeruginosa* is an serious emerging problem in the hospital. Vancomycin-resistant enterococcus (VRE) were not found in the ICU.

Conclusion

The incidences of VAP and CR-BSI were comparable to the National Nosocomial Infection Surveillance (NNIS) report. But the incidence of CR-UTI was over the 90th percentile. Antibiotic resistance has become a serious problem.

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การติดเชื้อในผู้ป่วยที่สอดใส่อุปกรณ์ และรูปแบบการดื้อยาของเชื้อจุลชีพในหอผู้ป่วยหนักอายุรกรรม-ศัลยกรรมในโรงพยาบาลมหาวิทยาลัยในประเทศไทย

สมจิตร์ ทองปิยะภูมิ, มณฑา ณ นรงค์, นงลักษณ์ สุวลักษณ์, สีลม แจ่มอุลิตรัตน์, ประสบสุข อินทรักษา, จารุวรรณ บุญรัตน์, นงเยาว์ เกษตร์ภิบาล, อะเคื้อ อุณหเลขกะ

การศึกษาอุบัติการณ์ของการติดเชื้อ ในหอผู้ป่วยหนักอายุรกรรม-ศัลยกรรมโรงพยาบาลสงขลานครินทร์ ในผู้ป่วยที่มีการสอดใส่อุปกรณ์เข้าร่างกายใน 3 ตำแหน่งที่สำคัญ ได้แก่ การติดเชื้อปอดอักเสบในผู้ป่วยที่ใส่เครื่องช่วยหายใจ การติดเชื้อในกระแสโลหิตในผู้ป่วยที่ใส่สายสวนหลอดเลือดส่วนกลาง และการติดเชื้อในระบบทางเดินปัสสาวะในผู้ป่วยที่ใส่สายสวนปัสสาวะ นอกจากนี้ยังศึกษารูปแบบการดื้อยาของเชื้อจุลชีพ เก็บรวบรวมข้อมูลระหว่างเดือนมิถุนายน 2543 ถึงมีนาคม 2545 ผลการศึกษาพบว่าในจำนวนผู้ป่วยที่เข้ารับการรักษาในหอผู้ป่วยหนักทั้งสิ้น 1,422 ราย หรือคิดเป็น 9,370 ผู้ป่วย-วัน มีอุบัติการณ์ของการติดเชื้อปอดอักเสบในผู้ป่วยที่ใส่เครื่องช่วยหายใจ การติดเชื้อในกระแสโลหิตในผู้ป่วยที่ใส่คาสายสวนหลอดเลือดดำส่วนกลาง และการติดเชื้อในระบบทางเดินปัสสาวะในผู้ป่วยใส่คาสายสวนปัสสาวะ คิดเป็น 10.8/1,000 วันที่ใส่เครื่องช่วยหายใจ (95%C.I = 8.5 – 13.6), 2.6/1,000 วันที่ใส่สายสวนหลอดเลือดดำ (95% C.I = 1.5 – 4.4) และ 13.8/1,000 วันที่ใส่สายสวนปัสสาวะ (95%C.I = 10.7-17.5) ตามลำดับ เชื้อจุลชีพที่เป็นสาเหตุสำคัญของการติดเชื้อ ได้แก่ Escherichia coli, Acinetobacter baumannii, Pseudomonas aeruginosa, และ Klebsiella pneumoniae โดยมีเชื้อที่ดื้อยาต่อยาต้านจุลชีพดังนี้ methicillin-resistant Staphylococcus aureus, imipenem-resistant P. aeruginosa, ceftazidime-resistant A. baumannii, third-generation-cephalosporin-resistant K. pneumoniae และ quinolone-resistant E. coli คิดเป็นร้อยละ 68.8, 30.9, 68.5, 44.6, และ 38.3 ตามลำดับ เมื่อเปรียบเทียบกับ National Nosocomial Infection Surveillance (NNIS) พบว่าอุบัติการณ์การติดเชื้อปอดอักเสบในผู้ป่วยที่ใส่เครื่องช่วยหายใจ และการติดเชื้อในกระแสโลหิตในผู้ป่วยที่ใส่คาสายสวนหลอดเลือดส่วนกลางใกล้เคียงกัน ส่วนอุบัติการณ์การติดเชื้อในระบบทางเดินปัสสาวะในผู้ป่วยที่ใส่คาสายสวนปัสสาวะสูงกว่า NNIS อย่างมาก จึงนับเป็นปัญหาสำคัญเช่นเดียวกับปัญหาเชื้อดื้อยาต้านจุลชีพ