Microbiology, Risk Factors and Mortality of Patients with Intravenous Catheter Related Blood Stream Infections in the Surgical Intensive Care Unit: A Five-Year, Concurrent, Case-Controlled Study

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Objective: *The epidemiologic data of catheter related blood stream infections (CRBSI) is different in each type of Intensive Care Unit (ICU). The objectives were to identify microbiological patterns, risk factors and mortality analysis in the surgical intensive care unit (SICU).*

Material and Method: *All CRBSI cases were reviewed in a 60-months period from the 1st of January, 2005 through the 31st of December, 2009. Two or three control patients, who had been catheterized within three days and were free of CRBSI, were randomly selected from the ICU admissions registration book as the control group; demographic data, mortality, organisms found and antibiotic sensitivity were recorded and analyzed.*

Results: *In the 5-years period, 44 patients were diagnosed with a CRBSI and 129 patients who were without a CRBSI were selected. The total infection rate was 1.31 per 1,000 catheter-days. Nine patients who contracted a CRBSI (20.4%) expired. A primary diagnosis of gastrointestinal problems had shown the greatest risk for developing a CRBSI (69.7%). In proportions of gram negative bacteria:gram positive bacteria:fungus, this was measured at 43:36:21 respectively. Staphylococcus aureus was the most common gram positive bacteria found. Klebsiella pneumoniae, Enterobacter cloacae and Pseudomonas aeruginosa were the three most common gram negative bacteria found. The chance of developing a CRBSI was significantly increased after 10 days of catheterization. The mortality probability of gram negative bacterial infections and fungal infections increased over time. This was in contrast to gram positive bacterial infections, which decreased over time despite having shown the highest possibility of death earlier in catheter days. As for multivariable analyses, catheterization of patients in the general wards was the sole independent risk factor of CRBSI occurrences (OR = 8.67, p<0.01) and the males (OR = 7.20, p = 0.03) have shown the highest risk factors for mortality.*

Conclusion: *The occurrence of gram-negative bacteria and gram-positive bacteria related CRBSI was similar, but the probability patterns of increasing the catheter days relating to CRBSI occurrence and mortality rates were different. Catheterization in the general wards was the only independent risk factor found for contracting a CRBSI in our institute. Males had the highest risk for mortality.*

Keywords: *Catheter related blood stream infection, Catheter, Bacteremia, Blood stream, Critical illness, Surgical ICU, Intensive care, Nosocomial infection, Mortality analysis*

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Intensive care units (ICU) have shown the highest prevalence of heath care associated infections (HAI)[1]. Catheter related blood stream infections (CRBSI) are one of the important HAIs and count for approximately 20 percent of all HAIs[1]. Although there were no differences on mortality outcomes, this complication was responsible for longer intensive care unit stays, lengths of stay in the hospital that have led to increased health care costs and increased resource utilization[2-4]. The organisms responsible for CRBSI have changed over time and are dependent on the hospitals' level of care and the patients' underlying diseases[5]. Therefore, consideration regarding these factors is an important component for selecting the appropriate treatments, in particular, the selection of

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an antimicrobial. In addition, knowledge of CRBSI risk factors leads to determining the policies for the prevention of these infections.

The surgical intensive care unit (SICU) is one of the clinical areas that use the greatest number of central venous catheters. In the SICU at the Chiang Mai University Medical Center, more than 1300 central venous catheters are inserted by physicians and surgeons annually. Although a surveillance program monitoring nosocomial infections has been introduced at our facility, the local risk factors for developing a CRBSI are still unknown. The purpose of the present study is to describe the microbiological features, sensitivity patterns of CRBSI organisms and their mortality outcomes. This study will also demonstrate the independent risk factors associated with CRBSI occurrence in our institute.

Material and Method

The authors used a concurrent, case controlled design for the present study. The present study was approved by Ethics Committee of Faculty of Medicine, Chiang Mai University (Certificated approval number 369/2009). The authors retrospectively collected the cases of patients who acquired CRBSI from the database of the infectious control unit at the Maharaj Nakorn Chiang Mai Hospital, Faculty of Medicine, Chiang Mai University. There are 46 beds in the SICU. These include an adult surgical ICU that contains ICU beds for patients in five subdivided units (general, trauma, cardio-thoracic, neurosurgery and burn units).

All ICU patients had been prospectively surveyed for CRBSI by infection control nurses and information was subsequently reported to the hospital infectious control center. Aerobic blood cultures for ICU patients were identified by a standard, clinical, microbiological laboratory. The criteria for a CRBSI are an infection in a patient who has had a central venous catheter inserted and which other sources of infection were ruled out. Additionally, the criterion used in diagnosing the CRBSI was obtained from IDSA guidelines, 2009, with the use of a semi-quantitative method[6-8].

The cases of CRBI noted during the period from January 1st, 2005 to December 31st, 2009 were reviewed. After, a CRBSI case and date of catheterization was obtained, two or three control patients who had been catheterized within three days of the CRBSI case and had not developed a CRBSI were randomly selected from the SICU admission record.

Demographic data, admission specialty, underlying disease (Charlson's comorbidity index), severity of the patients' disease (Acute Physiologic And Chronic Health Evaluation II, APACHE II score), the type and site of catheter, number of catheter days, place of catheterization, complications following the insertion, hospital length of stay, mortality, causative organisms, and antimicrobial susceptibilities were collected.

Data were analyzed using the STATA 11.0 software. The Pearson's Chi-square was used for measuring categorical variables. The Student's t-test and the Mann-Whitney U test were used for normal distribution variables and non-parametric continuous variables, respectively. Confounding factors were observed from the primary analysis as stated above. These were set at different significant levels at a p-value of less than 0.05 and had been analyzed together with theoretical factors, which could have involved the occurrence of the outcomes. Age had not been included in the model because it was a variable in the APACHE II scores. In the mortality and risk factor analysis, outcome records of mortality and CRBSI numbers were collected for the individual patients. Complete outcomes were rechecked at the patients' discharge from the hospital. In the cases of recurrence of infections for a patient, it recorded the mortality outcome at the end of treatment for each episode of infection. The most concerning confounder was controlled in analysis by the multivariable regression model and was reported with adjusted odds ratios.

Results

During the 5-year period, the infectious control center reported 44 cases of CRBSI over 33,384 catheter days (1.31 per 1,000 catheter-days). The average annual CRBSI rate per 1,000 catheter days for 5 consecutive years were 1.46, 1.22, 1.64, 1.45 and 0.82, respectively. The mortality rate was at 20.4 percent (9 in 44 patients). One hundred and twenty-nine of the concurrent control patients were randomly selected. The control patients were significant higher in years of age and their APACHE II scores but had shorter catheter days and shorter hospital lengths of stay (Table 1). There were no differences between the groups in terms of insertion sites, catheter types and mortality rates (Table 1). However, most cases were catheterized in a non-emergency setting (73.8%). A total of 40% of the cases were admitted for nutritional support. On the other hand, there were slightly higher incidences of emergent

Table 1. Demographic data of case and control

	Case (n = 44)	Control (n = 129)	p-value
Age in years (SD)	47.4 (16.1)	62.2 (17.0)	<0.01
Male (%)	29 (65.9)	84 (65.1)	0.92
Infection at the insertion date	9 (21.4)	42 (32.6)	0.17
Catheter day (SD)	13.8 (4.1)	7.1 (4.8)	<0.01
Length of stay (SD)	69.10 (39.33)	26.76 (26.78)	<0.01
Charson's comobidity index (SD)	1.3 (1.6)	1.4 (1.6)	0.63
APACHE II score (SD)	9.8 (5.7)	13.6 (7.2)	<0.01
Underlying disease			
Coronary artery disease	2 (4.8)	10 (7.8)	0.51
Chronic kidney disease	2 (4.8)	19 (14.7)	0.09
Diabetic mellitus	3 (7.1)	14 (10.9)	0.49
Others	18 (42.9)	38 (29.5)	0.11
Specialties			
Gastrointestinal	23 (52.3)	44 (34.1)	0.03
Non-gastrointestinal	21 (47.7)	85 (65.9)	
Vascular	3 (6.8)	19 (14.7)	
Hepato-biliary-pancreas	3 (6.9)	30 (23.3)	
Cardio-thoracic	3 (6.8)	9 (7.0)	
Trauma and neurosurgery	10 (22.7)	6 (4.7)	
Others	3 (6.9)	21 (16.3)	
Insertion type			
Emergency	11 (26.2)	66 (51.2)	<0.01
Non-emergency	31 (73.8)	63 (48.8)	
Site of insertion			
Basilic vein	22 (52.4)	78 (60.5)	0.24
Internal jugular vein	7 (16.7)	27 (20.9)	
Subclavian vein	13 (31.0)	24 (18.6)	
Type of catheter			
Single lumen	25 (59.5)	72 (55.8)	0.20
Cut down	9 (21.4)	43 (33.3)	
Tripple lumen	8 (19.1)	14 (10.6)	
Indication of insertion			
Hemodynamic monitor	26 (59.1)	124 (96.1)	<0.01
Nutritional support	18 (40.9)	5 (3.9)	
Initial insertion ward			
ICU	19 (43.18)	120 (93.0)	<0.01
General ward	25 (56.8)	9 (7.0)	
Mortality	9 (20.4)	29 (22.5)	0.78

catheter insertions (51.2%) in the control group. These procedures were done for hemodynamic monitoring purposes (96.1%).

With regard to all of the CRBSI cases, the two highest incidences were in patients who were admitted for gastrointestinal (GI) surgery and neurosurgery, 52.3% and 22.7%, respectively. These cases accounted for two-thirds of all CRBSI cases. However, the other principal admission disciplines had shown similar incidences (Fig. 1). Almost 80% of CRBSI was cultured as bacterial infections comprised of gram negative bacterial infections at 43.2% and gram positive bacterial infection at 36.3%. The three most common gram negative organisms were found to be *Klebsiella pneumonia* (5/19; 26.3%), *Enterobacter cloacae* (4/19; 21.1%) and *Pseudomonas aeruginosa* (3/19; 15.7%) (Table 2). Most infected patients found with gram positive bacteria were noted as *Staphylococcus spp.* (15/16; 93.8%). *Staphylococcus aureus* was the most common gram positive CRBSI (9/16; 56.3%) in which the Methicillin resistant staff aureas (MRSA) to the Methicillin sensitive staff aureus (MSSA) the ratio was

two to one (6/16 vs. 3/16). The remaining cultures had shown coagulase negative *Staphylococcus spp.* (6/16; 37.5%) and *Enterococus faecalis* (1/16; 6.3%). Almost 20% of the CRBSI cases were fungal infections in which the majority of the cases cultured as non-*albicans spp*. More than 70% of the gram negative bacteria related CRBSIs had shown sensitivities to Imipenem, Meropenem, Netilmycin and Piperacillin-tazobactam. Vancomycin was the only antibiotic that exhibited sensitivity for gram positive organisms in our setting (Fig. 2)

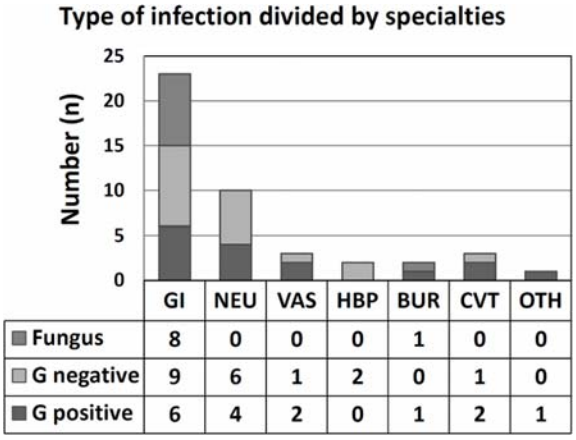

Fig. 1 Number of CRBSI divided by specialties [GI = gastrointestinal; NEU = neurosurgery; VAS = vascular; HBP = hepatobiliary pancreas; BUR = burn; CVT = cardio-vascular-thoracic (include chest); OTH = other; G negative = gram negative; G positive = gram positive].

The authors analyzed the risk factors associated with CRBSI using multivariable analysis that were adjusted by APACHE II scores, numbers of catheter days, catheter insertion indications and the site of the catheterization. According to this model, only insertion in the general ward proved to be a significant risk factor [OR 8.67 (2.84-26.43); p<0.01]. Use of triple lumen catheters, the need for parenteral nutrition and patients at a younger age had exhibited a higher tendency of developing CRBSIs (Table 3). In the CRBSI patients, mortality risks were significant higher in males and with catheterizations with triple lumen type catheters after the model was adjusted by the disease severity with APACHE II scores (Table 3).

Regarding the probability of CRBSI occurrence on the day of catheterization (Fig. 2), CRBSI had shown an infection by gram positive bacteria. Gram negative bacteria had shown a similar occurrence at the first ten days of catheterization but the occurrence of gram negative bacteria had shown slightly higher levels following the ten-day period. Although fungal infections had the lowest CRBSI occurrence at the initial period, the occurrence was raised dramatically after 14 days of having an indwelling catheter (Fig. 3).

Regarding mortality outcomes (Fig. 4), gram positive bacterial infections had the highest probability on mortality rates in the first 10 days. However, the

Table 2. Isolated organisms of CRBSI divided by discharge status

	All (n = 44)	Dead (n = 9)	Survive (n = 33)
Gram negative (%)	19 (43.2)	4 (44.4)	15 (42.9)
Escherichia coli (non-ESBL)	1 (2.3)	0 (0)	1 (2.9)
Escherichia coli (ESBL)	1 (2.3)	0 (0)	1 (2.9)
Enterobacter cloacae	4 (9.1)	1 (11.1)	3 (8.6)
Klebsiella pneumonia	5 (11.3)	0 (0)	5 (14.3)
Pseudomonas aeruginosa	3 (6.8)	1 (11.1)	2 (5.7)
Stenotrophomonas maltophilia	2 (4.5)	1 (11.1)	1 (3.0)
Acinetobacter baumanii	2 (4.5)	0 (0)	2 (5.7)
Chryseobacterium indologenes	1 (2.3)	1 (11.1)	0 (0)
Gram positive (%)	16 (36.4)	4 (44.4)	12 (34.3)
MRSA	6 (13.6)	3 (33.3)	3 (8.6)
MSSA	3 (6.8)	0 (0)	3 (8.6)
Coagulase negative staphylococus	6 (13.6)	1 (11.1)	5 (14.3)
Enterococus faecalis	1 (2.3)	0 (0)	1 (2.9)
Fungus (%)	9 (20.4)	1 (11.1)	8 (22.9)
Candida albicans	2 (4.5)	1 (11.1)	1 (2.9)
Candida spp.	7 (15.9)	0 (0)	7 (20.0)

MRSA = methicillin resistance staphylococcus aureus; MSSA = methicillin resistance staphylococcus aureus

Table 3. Multivariable logistic regression analysis of CRBSI occurrence (risk factors) and mortality

	Occurrence OR (95%CI)*	p-value	Mortality OR (95% CI)**	p-value
Age (years)	0.97 (0.94-1.00)	0.07	1.04 (0.98-1.09)	0.16
Male	0.68 (0.25-1.85)	0.45	7.20 (1.15-44.94)	0.03
Emergency	1.16 (0.42-3.19)	0.77	0.27 (0.03-2.32)	0.23
Infection at the insertion date	0.42 (0.13-1.39)	0.16	1.17 (0.17-8.78)	0.88
Charlson's morbidity score	1.12 (0.85-1.46)	0.42	1.55 (0.92-2.62)	0.10
Catherization at general ward	8.67 (2.84-26.43)	<0.01	0.28 (0.04-1.83)	0.19
Parenteral nutrition	3.91 (0.92-16.53)	0.06	0.96 (0.12-7.40)	0.97
Gastrointestinal surgery	0.64 (0.20-2.01)	0.45	1.14 (0.17-7.80)	0.89
Venous site				
Basilic vein	Reference		Reference	
Internal jugular	0.83 (0.26-2.72)	0.76	0.67 (0.06-7.59)	0.74
Subclavian vein	0.86 (0.26-3.03)	0.84	0.35 (0.03-3.68)	0.38
Type				
Cavafix	Reference		Reference	
Cut down	1.95 (0.62-6.11)	0.25	2.53 (0.29-22.39)	0.40
Triple lumen	3.16 (0.84-11.88)	0.09	10.60 (1.21-22.39)	0.03

*Adjusted by APACHE II score, catheter day, indication for catheter insertion and insertion ward
** Adjusted by APACHEII in CRBSI patients

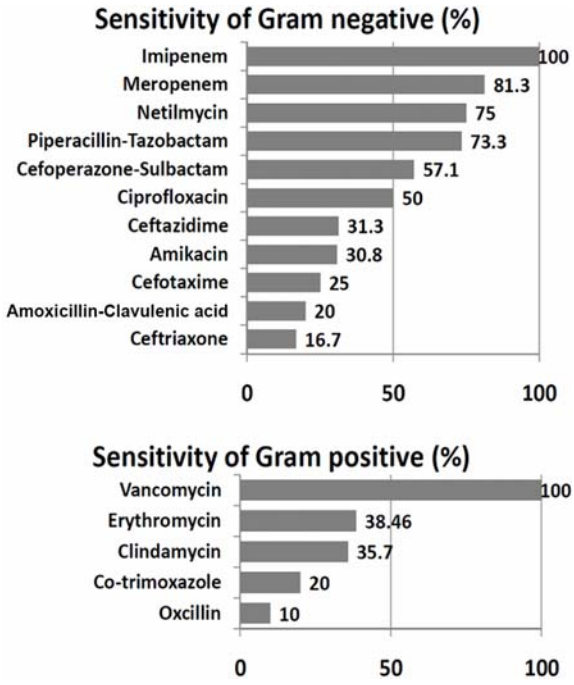

Fig. 2 Antibiotics sensitivity patterns.

trend decreased over time. Contrarily, gram negative bacterial infections and fungal infections had shown a lower probability for mortality than gram positive bacterial infections at the initial period but the trend increased with extended catheter days. The mortality of those suffering gram negative bacterial infections became higher than those with gram positive infections 2 weeks post catheterization. This finding was also found in those with fungal infections at 3 weeks post catheterization (Fig. 4).

Discussion

The present study is the first report to determine the risk factors of CRBSI occurrence and mortality in a Thai, northern region, university based, tertiary hospital. The authors approached the results with a concurrent case-controlled design or what is known as incidence, density sampling. The present study is designed for matching cases and controls for the duration of the follow-up period[9]. Advantages of this design are to give a risk estimation, cohort design and to reduce the selection bias by choosing controls randomly. Up to three controls were randomly selected to maximize the study's power. At five years of surveillance, the incidence density of CRBSI in our institute had shown a lower incidence when compared with the larger epidemiologic studies done on Italian ICUs and in the Malaysian report (Our study 1.31: Italy 1.90: Malaysian 9.43)[10,11]. The CRBSI cases had significant more catheter days and lengths of hospital stays but no differences were found on hospital mortality. These findings were similar to a previous, economic study[2]. Although the authors randomly selected the controls, they were significant higher in severity scores (APACHE II) and in years of

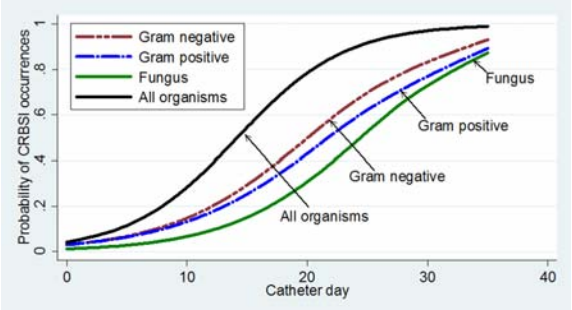

Fig. 3 Probability of CRBSI occurrences on increment of catheter day.

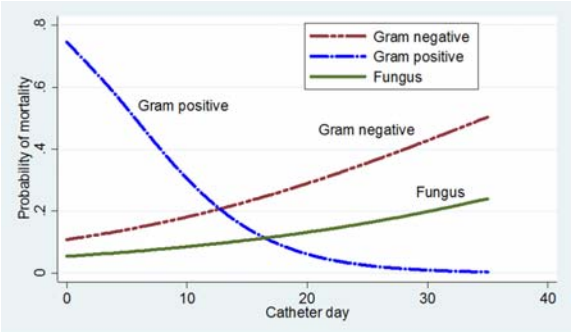

Fig. 4 Probability of mortality in CRBSI cases on increment of catheter day divided by organism types.

age (Table 1).

Regarding the infecting organisms, both gram negative bacterial and gram positive bacterial CRBSIs had nearly identical proportions. The percentage of microbiologic isolation of GN:GP:fungus was 44:36:20. This ratio was different from a previous SICU report in the United State (US) in which the ratio was 20:75:5[3]. In addition, a large microbiologic report of blood stream infections from Spain had also shown the same predisposition that gram positive pathogens were higher in the proportion and thus a burden for blood stream infections[5]. However, this surveillance data found higher fungal infection rates than previously reported. This was more noticeable in gastrointestinal surgical patients[3]. This finding might be explained by the fact that there tends to be more parenteral infusions and prolonged catheter days for this population of patients (Fig. 3 and 4)[12,13]. The six most common organisms isolated at our institute were (1) *Staphylococcus aureus*, (2) *Candida spp.*, (3) *Coagulase negative Staphylococcus*, (4) *Klebsiela pneumoniae*, (5) *Enterobacter cloacae* and (6) *Pseudomonas aeruginosa*. These were different from previous reports as shown; USA, *Staphylococcus epidermidis*; Malaysia, *Klebsiella pneumonia*, and Pawar et al; *Escherichia coli*[3,11,14]. In addition, the authors found different patterns of probability of CRBSI's occurrence and mortality for each organism and these increased with each catheter day. Gram negative bacterial infections had the highest trend of CRBSI occurrence and had shown an increased tendency for mortality over time (Fig. 3 and 4). In our opinion, the higher mortality from gram positive bacterial infections in the early period could possibly be explained by a lower incidence of gram positive infections in the SICU and thus, no empirical antibiotic protocols for these bacterial infections.

Drug resistant organisms are a critical problem in current antimicrobial practices[15,16]. Imipenem, Meropenem, Netilmycin and Piperacillin-Tazobactam cover more than 70% of the gram negative organisms that are related to CRBSIs. These findings were lower than had been reported in a previous report done in Canada in which these antibiotics susceptibility for gram negative blood stream infections were at nearly 90%[17]. In our opinion, based on institutional data, the inappropriate and frequent use of the antibiotics, Ciprofloxacin, Ceftriaxone, Ceftazidime, and Cefotaxime may have been responsible for the resulting poor susceptibility of gram negative bacteria in our institute. Regarding gram positive organisms, the antibiotic of choice is Vancomycin for CRBSIs because nearly 90% of organisms show susceptibility to this agent (Fig. 2). However, drug level monitoring is needed for titrating the dose of Vancomycin due to its narrow therapeutic index and the reduction of Vancomycin's efficacy against the bacteremia, MRSA[18].

APACHE II scores, the duration of the catheterization, the indications of catheter insertion and the site of the catheterization are reported as risk factors for CRBSI occurrence[11,12,14]. Gender, an emergent setting, existing infections on the date of insertion, Charlson's morbidity scores and the venous site were not significantly associated with CRBSIs occurrence. However, patients at a younger age, the necessity for parenteral nutrition and the use of triple lumen type catheters had shown a higher tendency for infections with p-values between 0.05-0.10. Interestingly, catheterization in a general ward has shown to be a significant predictor of CRBSI occurrence and these findings were in contrast to a previous report done in Malaysia in which catheters inserted in the ICU had resulted in the highest occurrence of CRBSIs[11]. This finding could be explained by: (1) non-compliance of

sterile techniques and proper barrier precautions during catheter insertion in the general ward setting during the study period, (2) no guidelines for catheter site care and dressings, (3) lower patient to nurse ratios (4) higher temperatures and humidity and (5) less experienced physicians. Elimination of these errors and strict adherence to prevention guidelines may possibly decrease future CRBSI occurrences[19]. Although controversies on the results of gender on severe sepsis outcomes exist[20], males have shown to be a significant independent factor on the mortality related to developing a CRBSI in our data. Differences in immune responses between the genders might be one explanation[21].

The advantages of this study are that it is the first report on risk factors, mortality and microbiological treatments at our institute. The authors analyzed risk factors using multi-variable logistic regression analysis for reducing the possible confounding effects. However, there were some limitations in the present study. First, the cases were retrospectively collected from a surveillance report from the infectious control unit. The incidence of CRBSI might be lower than found in our intensive surveillance due to cases that may have been overlooked. Second, concurrence of the controls in the ICU led to a problem of randomizing the patients' ages. Most SICU patients and post-operative, high risk, surgical patients were of an advanced age. As a result these results could confound our study. Third, the total number of patients who contracted a CRBSI and the information on the mortality of the patients were based on a small sample in the present study. Multiple logistic regression analysis may decrease the powers of detection. Finally, the retrospective severity scores and co-morbidity index calculation may be invalid and could present a higher tendency towards lower score estimations. Nevertheless, these findings encourage the institute's awareness and will further policy determination for CRBSI prevention as well as help to set appropriate institute antibiotic selection guidelines.

Conclusion

CRBSI with gram negative bacteria and gram positive bacteria had shown similar proportions. Probability patterns on the increasing catheter days on the occurrence of contracting CRBSIs and the mortality measured from gram negative bacteria, gram positive bacteria and fungus differed. Insertion in a general ward had shown to be the predominant, independent risk factor of developing a CRBSI at our institute. The male gender patients have shown a higher risk of mortality.

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Potential conflicts of interest

None.

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ลักษณะของเชื้อก่อโรค ปัจจัยเสี่ยงและอัตราการเสียชีวิตของการติดเชื้อในกระแสเลือดที่สัมพันธ์กับการใส่สายสวน หลอดเลือดดำในผู้ป่วยไอซียูศัลยกรรม: การศึกษาในกลุ่มศึกษาและควบคุม ในช่วงเวลาเดียวกันเวลา 5 ปี

เจริญ ชีวินเมธาศิริ, กวีศักดิ์ จิตตวัฒนรัตน์, กำธน จันทร์แจ่ม, ธิดารัตน์ จิรพงศ์เจริญลาภ, นเรนทร์ โชติรสนิรมิต

วัตถุประสงค์: ข้อมูลระบาดวิทยาของการติดเชื้อในกระแสเลือดที่สัมพันธ์กับการใส่สายสวนหลอดเลือดดำ มีความแตกต่างกันในไอซียูแต่ละแห่ง วัตถุประสงค์ของการศึกษานี้เพื่อระบุชนิดของเชื้อก่อโรค วิเคราะห์ปัจจัยเสี่ยง และอัตราการเสียชีวิตในผู้ป่วยไอซียูศัลยกรรม

วัสดุและวิธีการ: *ผู้นิพนธ์ทำการทบทวนผู้ป่วยที่มีการติดเชื้อจากสายสวนหลอดเลือดดำจำนวน 60 เดือน ระหว่างวันที่ 1 มกราคม พ.ศ. 2548 ถึง 31 ธันวาคม พ.ศ. 2552 โดยจะทำการสุ่มเลือกกลุ่มควบคุมจำนวน 2-3 ราย ต่อผู้ป่วย 1 ราย ในช่วงระยะเวลาเดียวกันกับผู้ป่วยบันทึกและวิเคราะห์เปรียบเทียบข้อมูลพื้นฐานของผู้ป่วย การเสียชีวิต เชื้อก่อโรค และการตอบสนองของยาปฏิชีวนะในห้องปฏิบัติการ*

ผลการศึกษา: *ในช่วงดังกล่าวผู้ป่วยที่ได้รับการวินิจฉัยว่ามีการติดเชื้อฯ จำนวน 44 ราย กลุ่มควบคุม ที่สุ่มเลือกในเวลาเดียวกันจำนวน 129 ราย อัตราการติดเชื้อคิดเป็น 1.31 ครั้งต่อ 1,000 วัน ของการใช้สายสวนฯ ผู้ป่วยที่มีการติดเชื้อฯ จำนวน 9 ราย เสียชีวิต (ร้อยละ 20.4) ผู้ป่วยเหล่านี้ส่วนใหญ่มีโรคที่ให้การวินิจฉัยในระบบทางเดินอาหาร (ร้อยละ 69.7) สัดส่วนของเชื้อกรัมลบต่อกรัมบวกต่อเชื้อรา คือ ร้อยละ 42.9 ต่อ 35.7 ต่อ 21.4 โดยพบเชื้อ Staphylococus aureus เป็นเชื้อกรัมบวกที่พบบ่อยสุดและ Klebsiella pneumoniae, Enterobacter cloacae และ Pseudomonas aeruginosa เป็นเชื้อกรัมลบ 3 ลำดับแรกที่พบบ่อยสุดตามลำดับ เมื่อเวลาของการใส่สายสวนเพิ่มขึ้นจะเพิ่มโอกาสในการติดเชื้อฯ ไม่ว่าจากเชื้อชนิดใดโดยเฉพาะหลังจากวันที่ 10 หลังการใส่สายสวน ความเสี่ยงต่อการเสียชีวิตของการติดเชื้อจากกรัมลบและเชื้อราจะเพิ่มขึ้นเมื่อเวลาผ่านไป ซึ่งแตกต่างจากเชื้อกรัมบวกที่จะลดลงแม้ว่าจะพบว่ามีโอกาสที่สูงสุดในช่วงแรกก็ตาม ในการวิเคราะห์แบบพหุถดถอยหลายตัวแปร พบว่าการใส่สายสวนฯ จากหอผู้ป่วยสามัญเป็นปัจจัยเสี่ยงของการติดเชื้อฯ (OR 8.67, p<0.01) และเพศชายเป็นปัจจัยเสี่ยงต่อการเสียชีวิต (OR 7.20, p = 0.03)*

สรุป: *สาเหตุของการติดเชื้อจากสายสวนฯ ด้วยเชื้อกรัมลบและกรัมบวกมีสัดส่วนที่ใกล้เคียงกัน ความเสี่ยงต่อการเกิด การติดเชื้อและการเสียชีวิตของเชื้อกรัมลบ กรัมบวก และเชื้อราจะมีรูปแบบที่ต่างกัน หอสามัญเป็นปัจจัยเสี่ยงต่อการใส่สายสวนฯ ในโรงพยาบาลที่ทำการศึกษา และเพศชายเป็นปัจจัยเสี่ยงต่อการเสียชีวิต*