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Original Article

Risk factors of nosocomial bloodstream infections in surgical intensive care unit

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Abstract: Background: Many studies have examined risk factors of nosocomial bloodstream infections. However risk factors of nosocomial bloodstream infections in surgical intensive care unit have never been reported. The aim of this study was to investigate this topic. Methods: Retrospective surgical intensive care unit patients' data were collected in a tertiary hospital from January 2010 to August 2014. Infected and non-infected patients were compared with univariate analysis of categorical variables to obtain statistical significance risk factors. Then multivariate logistic regression analysis was performed to acquire the final risk factors. Results: 98 patients were diagnosed with nosocomial bloodstream infections in total. Mortality rate was 29.6% (n=29). The data indicated gram-positive cocci were the main pathogens (64.3%; n=63). Multivariate logistic analysis indicated that age (>65 years old) (OR, 2.297; CI95, 0.870 to 6.062), acute physiology and chronic health evaluation II score (>18) (OR, 6.981; CI95, 2.330 to 15.865), multiple organ dysfunction score (>8) (OR, 9.857; CI95, 6.395 to 19.505), mechanical ventilation (OR, 4.583; CI95, 2.134 to 10.956), central venous catheter (OR, 5.875; CI95, 2.212 to 13.456) and selective surgery (OR, 3.455; CI95, 3.442-9.235) were risk factors of nosocomial BSI. Conclusions: Patients with nosocomial bloodstream infections in surgical intensive care unit setting often have a poor prognosis. Age (>65 years old), chronic health evaluation II score (>18), multiple organ dysfunction score (>8), usage of mechanical ventilation, central venous catheter and selective surgery can be regarded as risk factors.

Keywords: Bloodstream infections, nosocomial, risk factors, surgical, intensive care unit

Introduction

Nosocomial bloodstream infections (BSI) are common nosocomial infections and may increase mortality and morbidity [1-4]. Also these infections add burden to healthcare [5, 6]. Especially when such kinds of infections occur in patients in intensive care units (ICU), they are associated with a high mortality rate, additional hospital days and excess hospital costs [7]. Garrouste-Orgeas M, et al reported nosocomial BSI was associated with a 3-fold increase in mortality in ICU [8]. Some studies suggested surgery and admission to ICU was closely related to nosocomial BSI [9, 10]. Patients admitted to ICU are at the greatest risk of acquiring nosocomial infections, partly because of their serious underlying disease, but also by exposure to life-saving invasive procedures [11]. In the meantime, bacteremias have become more frequent in the ICU [12]. Patients underwent major surgeries experience suppressive immunity function due to blood loss, anesthesia, and tissue damages. Because all these above factors, patients in surgical intensive care unit (SICU) are extremely vulnerable to nosocomial BSI. In our hospital clinical experiences, nosocomial BSI happened often in SICU and frequently attracted physicians' attention with patients' condition rapid change to worse. Many studies have examined risk factors of nosocomial BSI [13-19]. However no literature demonstrated predictors of nosocomial BSI in SICU at present. In this study, predictors were explored in a SICU.

Materials and methods

Setting and definition

Ningbo University affiliated Yin Zhou Hospital is a 1209-beds tertiary hospital with a 5-beds

Table 1. Distribution of pathogens in nosocomial BSI

Pathogens	Nosocomial BSI n (%)
Gram-positive cocci	
Staphylococcus aureus	50 (51.0%)
Enterococcus faecalis	8 (8.2%)
Enterococcus faecium	3 (3.0%)
Enterococcus (other)	2 (2.1%)
Gram-negative bacilli	
Klebsiella spp.	*8 (8.2%)*
Escherichia coli	6 (6.1%)
Enterobacter spp.	5 (5.2%)
Pseudomonas aeruginosa	3 (3.0%)
Gram-positive cocci and gram-negative bacilli	
Mixed microorganisms	3 (3.0%)
Fungi	
Candida albicans	10 (10.2%)
Total	98 (100%)

SICU in Ningbo, China. A retrospective study was conducted among patients admitted into SICU from January 2010 to August 2014. During this period, altogether 569 surgical patients were included. Nosocomial BSI was defined as new positive blood culture after 48 hours of SICU admission and met criteria for BSI per CDC definitions [20]. This study was reviewed and approved by ethics committee of Ningbo University affiliated Yin Zhou Hospital.

Study design

After the definition applied, 98 patients were diagnosed with nosocomial BSI. Another non-infected 98 patients were randomly selected during the same period of time. All patient's clinical records information were reviewed. 98 infected patients and 98 non-infected patients were compared with selected variables which were as follows, sex, age (>65 years old), acute physiology and chronic health evaluation II score (APACHE II score) (>18), mechanical ventilation (MV), urinary catheter, central venous catheter (CVC) (>5 days), H2 blockers, blood sugar (>11.1 mmol/l), nasogastric tube, serum albumin (<30 g/L), transfusion, coma, multiple organ dysfunction score (MODS score) (>8) and surgery. Each patient's APACHE II score was evaluated according to study of Knaus WA, et al [21]. It was done basing on clinical records within first 24 hours in the SICU. MODS score was calculated on admission as well, using the method described in literature of Marshall JC, et al [22]. Those statistical significant variables were obtained.

Statistical analysis

Data analysis was under the help of SPSS software 17.0 for windows (SPSS Inc, Chicago, IL). For frequency analysis of variables, Chi-square test was used. Univariate analysis was performed using the Mann-Whitney-test (for not normally distributed data) or two sample *t*-test (for normally distributed data) for continuous variables. A multivariate stepwise logistic regression analysis was conducted using variables with significant differences or association in univariate analysis. The odds ratios (OR) and their corresponding 95% CIs (confident intervals) for each variable were also calculated. Statistical significance was considered when P values were <0.05.

Results

Patient characteristics

During January 2010 to August 2014, a total of 98 patients experienced 113 episodes of nosocomial BSI in hospital's SICU. The average age for this population was 54.3±12.1 years; 56.1% were male. The underlying conditions on admission to SICU were as follows: cerebrovascular accidents (34.7%), severe traumatic cerebral injuries (23.5%), multiple traumatic injuries (22.4%) and major selective surgeries (19.4%). The average time from admission to confirmed onset of nosocomial BSI was 9.2±8.4 days, ranging from 3 to 55 days. 29 patients died.

Distribution of microorganisms

Table 1 displays the distribution of microorganisms leading to nosocomial BSI amid 98 patients. The data indicated gram-positive cocci were the main pathogens (64.3%; n=63), followed by gram-negative bacilli (22.5%; n=22), gram-positive cocci and gram-negative bacilli mixed microorganisms (3.0%; n=3) and fungi (10.2%; n=10).

Analysis of variables and predictors

Table 2 shows univariate analysis of possible variables contributing to nosocomial BSI, including patients' basic characteristics.

Table 2. Univariate analysis of categorical variables for nosocomial BSI

	Infected n=98 (%)	Non-infected n=98 (%)	*P* value
Male sex	38 (38.8)	42 (42.9)	0.724
Age (>65 years old)	37 (37.8)	25 (25.5)	0.033
Cerebrovascular accidents	34 (34.7)	29 (29.6)	0.076
Severe traumatic cerebral injuries	23 (23.5)	18 (18.4)	0.407
Multiple traumatic injuries	22 (22.4)	26 (26.5)	0.356
MODS score (>8)	36 (36.7)	19 (19.3)	0.028
APACHE II score (>18)	36 (36.7)	22 (22.4)	0.030
Mechanical Ventilation	50 (51.0)	28 (28.6)	0.011
Urinary catheter	45 (45.9)	39 (39.8)	0.216
Nasogastric tube	37(37.8)	44 (44.9)	0.687
Central venous catheter	35 (35.7)	24 (24.5)	0.039
H2 blockers	52 (53.1)	57 (58.2)	0.621
Blood sugar (>11.1 mmol/L)	48 (49.0)	45 (46.0)	0.213
Serum albumin (<30 g/L)	40 (40.8)	30 (30.6)	0.040
Transfusion	28 (28.6)	23 (23.5)	0.534
Coma	42 (42.9)	28 (28.6)	0.032
Surgery	68 (69.4)	50 (51.0)	0.016

Table 3. Univariate analysis of categorical variables for nosocomial BSI related different outcomes

	Survivors n=69 (%)	Non-survivors n=29 (%)	*P* value
Age (>65 years old)	19 (19.3)	18 (62.1)	0.026
MODS score (>8)	15 (21.7)	21 (72.4)	0.015
APACHE II score (>18)	13 (18.8)	23 (79.3)	0.014
Mechanical Ventilation	25 (36.2)	25 (86.2)	0.009
Central venous catheter	9 (13.0)	26 (89.7)	0.002
Serum albumin (<30 g/L)	20 (29.0)	20 (69.0)	0.016
Coma	23 (33.3)	19 (65.5)	0.031
Open trauma surgery	24 (34.8)	9 (31.0)	0.082
Selective surgery	20 (29.0)	15 (51.8)	0.028

Conclusively, male sex was not a variable for infection. There was statistically significant difference in >65 years old age. The underlying diseases didn't have any influences on infection except for surgery. Serum albumin (<30 g/L) had connection with infection, but blood sugar (>11.1 mmol/L) and use of H2 blockers didn't. Statistically significant differences also existed in use of MV and CVC, while not in other health care associated aggressive procedures such as urinary catheter and nasogastric tube. MODS score (>8) and APACHE II score (>18) were potential variables responsible for infection.

Table 3 presents univariate analysis of categorical variables for nosocomial BSI related different outcomes. Consequently, statistical significant variables consisted of age (>65 years old), MODS score (>8), APACHE II score (>18), MV, CVC, serum albumin (<30 g/L), coma and selective surgery, while open trauma surgery was not a contributing variable.

Table 4 displays the adjusted OR and 95% CI of the variables suggested by multivariate logistic regression model to be independent predictors. Multivariate logistic showed that age (>65 years old) (OR, 2.297; CI 95, 0.870 to 6.062), APACHE II score (>18) (OR, 6.981; CI 95, 2.330 to 15.865), MODS score (>8) (OR, 9.857; CI 95, 6.395 to 19.505), MV (OR, 4.583; CI 95, 2.134 to 10.956), CVC (OR, 5.875; CI 95, 2.212 to 13.456) and selective surgery (OR, 3.455; CI 95, 3.442-9.235) were independent predictors of nosocomial BSI related mortality.

Discussion

Although many studies have examined the risk factors of nosocomial BSI either in ICU or non-ICU settings [14, 23, 24], in older population [15, 16] and in cohort studies [13, 25]. No literature has focused on predictors of nosocomial BSI in a SICU. This study has made an initial step on it and provided some information. In our study, we have found five independent predictors, among which MODS score was seldom addressed in previous studies.

Patients in SICU are usually critically ill, immuosuppresive and body defensive barriers impaired. So they are prone to nosocomial BSI. Nosocomial BSI is a major cause of mortality, morbidity and medical cost in this population. Particularly, in older patients, it is significantly associated with increases in 90-day mortality, increased length of hospital stay, and increased costs of care [26]. This is consistent with our findings that age (>65 years old) was an independent predictor.

Table 4. Multivariate logistic regression analysis of the independent predictors of nosocomial BSI related mortality

	S_b	Wald x^2	*P* value	*OR* value	95% *CI*
Age (>65 years old)	0.495	2.820	0.035	2.297	0.870-6.062
APACHE II score (>18)	0.782	7.225	0.017	6.981	2.330-15.865
MODS score (>8)	0.837	11.620	0.027	9.857	6.395-19.505
Mechanical Ventilation	0.432	4.113	0.044	4.583	2.134-10.956
Central venous catheter	0.562	4.511	0.012	5.875	2.212-13.456
Selective surgery	0.679	5.854	0.017	3.455	3.442-9.235

CVC is often used in SICU patients, facilitating drug administration, infusion and parenteral nutrition. CVC related infections were the mostly investigated issues in many studies [17-19, 27-29] and some regarded CVC as the most common cause of nosocomial BSI [30, 31]. Like these studies, our data also showed evidences of poor outcome when it occurred in SICU patients. Prevention of such infections is no easy job. CVC insertion, maintenance and delayed removal can cause this problem.

The most common pathogen was Staphylococcus aureus (51.0%) in our findings. This is a similar result to other studies [14, 32]. It offers some guidance in empirical antibiotics selection in suspected nosocomial BSI before the return of blood culture results.

MV is frequently applied in ICU. Poor hand hygiene and suctioning techniques can lead to nosocomial pneumonia [24]. Pneumonia was viewed as a source of secondary nosocomial BSI [33]. Our study supported the correlation of MV and increased nosocomial BSI.

The findings of our study indicated high APACHE II score (>18) was a predictor for nosocomial BSI related death. APACHE II score was developed for predicting mortality in patients who were admitted to the critical care unit. It provides the clinician with a systematic evaluation and an improved understanding of how an individual patient's severity of disease influences outcome [21]. Some reports investigated associations between APACHE II score and nosocomial infections. Machi SUKA et al. reported that APACHE II score might be a good predictor of nosocomial infections in ICU patients and those who had an increased APACHE II score might be at high risk for nosocomial infections [34]. MODS score has been developed for use in critically ill patients [35]. It includes six organ systems score and can reflect the severity of organ dysfunction accurately. Often it is used as prognostic indicator in ICU evaluation and is fairly easy for clinician to apply. Our findings revealed patients with MODS score more than 8 were at high risk of dim prognosis resulting from nosocomial BSI. Interestingly, surgery was a risk factor of infection and selective surgery was a predictor in nosocomial BSI related infection, but open trauma surgery were not the same as selective surgery. This was because of open trauma surgery patients were usually young and without comorbidities in our study. We had limitations in our study. The observed population was a small group patients. The results would be more precise if more patients were included. In addition, if time factor was added into consideration about predictors of CVC and MV application. It would provide more details about this two predictors. Furthermore, more potential variables could be selected for analysis.

In conclusion, this study at first time shows some predictors of nosocomial BSI in SICU. It demonstrates that patients are vulnerable to nosocomial BSI and may have poor outcome if they have any of following conditions: age (>65 years old), high APACHE II score (>18), high MODS score (>8), usage of MV or CVC and selective surgery.

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Disclosure of conflict of interest

None.

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