Original Article

Clinical analysis of central venous catheter-related infections in patients in the emergency ICU

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BACKGROUND: Catheter-related infection (CRI) of the central vein is a common cause of nosocomial infection. This study was undertaken to investigate the pathogen culturing and risk factors of CRI in emergency intensive care unit (EICU) in order to provide the beneficial reference.

METHODS: From January 2008 to December 2010, a total of 1 363 patients were subjected to catheterization. In these patients, the peak CRI rate of the patients was determined by bacterial cultivation and blood bacterial cultivation.

RESULTS: CRI happened in 147 of the 1 363 patients using the central venous catheter. The peak rate of CRI was 10.79%, with an incidence of 3.05 episodes per 1 000 catheter days. Of the 147 patients, 46.94% had gram-negative bacilli, 40.14% had gram-positive cocci, and 12.92% had fungi. Unconditional logistic regression analysis suggests that multiple catheterization, femoral vein catheterization, the application of multicavity catheter, and the duration of catheterization were the independent risk factors for CRI.

CONCLUSION: The risk factors for catheter-related infections should be controlled to prevent the occurrence of nosocomial infection.

KEY WORDS: Central venous; Cather related infection; Femoral vein catheter; Multiple lumen catheter; Long-term indwelling catheter; Long-term use of antibiotics; Emergency intensive care unit; Nosocomial infection

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INTRODUCTION

Catheter-related infection (CRI) of the central vein is a common cause of nosocomial infection.[1] The incidence of CRI varies from 2% to 50% in patients.[2,3] The difference in incidence of CRI across studies may be related to the different diagnostic criteria used by different institutions, the underlying disease of the patients studied, the degree of severity of their illness, and the catheter material used. In this study, we carried out an etiological study of CRI in patients hospitalized at the Emergency Intensive Care Unit (EICU) of our hospital from January 2008 to December 2010. We aimed to explore the incidence, etiological characteristics and risk factors for CRI in the EICU so as to improve the prevention and treatment of CRI.

METHODS

Clinical data

A total of 1 363 patients, who had been admitted to the EICU of our hospital for central venous catheter placement from January 2008 to December 2010 were included. These patients included 876 males and 487 females, and their age ranged from 17 to 96 years, with an average of 65.3±12.7 years. An exclusion criterion was the placement of the central venous catheter at another department or hospital. The Institutional Review Board of the hospital approved the study and waived the requirement for individual patient consent.

Methods

The retrospectively collected data included: 1)

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patients' demographic information, date of infection, and pathogens detected; 2) related risk factors: age, gender, the use of a multi-lumen catheter, Acute Physiology and Chronic Health Evaluation II (APACHE II) score during catheter placement, number of catheter placements, long-term use of antibiotics, femoral vein catheter placement, and catheter indwelling time (in days).

Sampling method

Before catheter removal, two 5 mL of venous blood samples were collected percutaneously at the sites of catheter insertion in the bilateral upper limbs and the samples were separately put into culture flasks. At the site of catheter puncture, the skin was disinfected with iodine tincture and ethanol. The catheter was retracted and, under sterile conditions, the end of the catheter (about 5 cm long) was collected and put in a sterile culture tube. The tube was then immediately sent to the bacterial culture room. Culture of the catheter tip was done by rolling the catheter tip back and forth once on the blood agar and the presence of 15 CFU/Petri dish indicated a positive result. For the quantitative culture of blood collected from the puncture site, the presence of 100 CFU/mL was considered positive.

Methods of pathogen culture and susceptibility testing

Specimen culture was done using a Bact/Alert 3D automated culture instrument (Organon International, Oss, The Netherlands). Pathogens were identified using the VITEK®2 semiautomatic microbial system and VITEK®2 identification card (bioMérieux, Inc., Durham, NC). Susceptibility testing was done using the KB disk diffusion method. For drug-resistance enzyme-producing strains such as methicillin-resistant Staphylococcus and vancomycin-resistant Enterococci, the Minimal Inhibitory Concentration (MIC) diffusion method was used for further testing and confirmation. Fungus identification plus susceptibility testing was done using the ATB® FUNGUS 3 method. The results were judged in accordance with the Clinical and Laboratory Standards Institute (CLSI) 2007 standards.

Diagnostic criteria for CRI

The diagnostic criteria developed by the Critical Care Committee of the Chinese Medical Association in 2007 were used.[4] These included inflammation at the infection site, fever and positive culture for bacteria or fungi.

Statistical analysis

SPSS 13.0 (SPSS Inc., Chicago, IL) was used for statistical analysis. The relationship between the occurrence of infection and catheter indwelling time was examined using the Chi-square test. Possible factors related to catheter infection were included in a multivariate unconditional logistic regression analysis. A $P<0.05$ was considered statistically significant.

RESULTS

Incidence of CRI and etiological characteristics

Central venous catheters were used in 1363 patients in the EICU. Of these, 147 catheters had positive culture results, with a positive rate of 10.79%. All of the 147 catheters met the diagnostic criteria for CRI, and the CRI infection rate was 10.79%. CRI occurred 3.05 times per day per 1000 catheters.

Detection of pathogens

The main pathogens detected in patients with CRI were 69 strains of gram-negative bacilli (46.94%), including 27 strains of *Acinetobacter baumannii* (18.37%), 11 strains of *Escherichia coli* (7.48%) and 11 strains of *Klebsiella pneumoniae* (7.48%). Of the 59 strains of gram-positive cocci (40.14%) detected, 17 were *Staphylococcus epidermidis* (11.56%), 12 were *Staphylococcus haemolyticus* (8.16%) and 11 were *Staphylococcus aureus* (7.48%). The 19 strains of fungi (12.92%) included 5 strains of *Candida albicans* (3.40%), 4 strains of *Candida glabrata* (2.72%) and 4 strains of *Candida parapsilosis* (2.72%) (Figure 1).

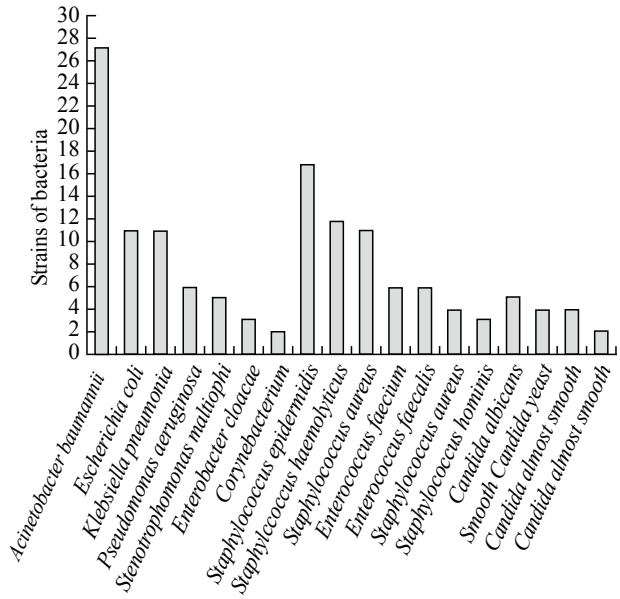

Figure 1. Distribution of pathogenic bacteria.

Relationship between infection and catheter indwelling time

The results of the Chi-square test showed that, with increased catheter indwelling time, the incidence of CRI also was increased (χ^2=24.994, P<0.001) (Figure 2).

Regression analysis of CRI-related risk factors

Multivariate unconditional logistic regression analysis was used to determine the factors related to CRI risk. The factors included age, gender, the use of a multi-lumen catheter, APACHE II score at catheter placement, repeated catheter placements, long-term use of antibiotics, femoral vein catheter placement, and long catheter indwelling time (>7 days). The results showed that age, use of a multi-lumen catheter, higher APACHE II score, repeated catheter placements, femoral vein catheter placement, and long catheter indwelling time (>7 days) were independent risk factors for CRI (Table 1).

DISCUSSION

Pathogens of CRI

In this study, the main pathogens of CRI were gram-negative bacilli (46.94%), gram-positive cocci (40.14%), and fungi (12.92%); *A. baumannii* was the predominant gram-negative bacillus (18.37%). Our finding is different from the majority of reports from China, which found that the main pathogens of CRI in the ICU were gram-positive bacteria.[5,6] The possible reasons for the difference could be that the patients in the EICU of our hospital were older, their diseases were more severe, and they had more underlying diseases (greater comorbidity). Some elderly patients had a long length of hospital stay and they were more prone to hospital-acquired infections. ICU patients often have a variety of combined infections. The use of broad-spectrum antimicrobial agents can inhibit the normal flora in the body, resulting in dysbacteriosis. Strains sensitive to antimicrobial drugs are inhibited, resulting in significant proliferation of drug-resistant strains and nosocomial infection.[7] *A. baumannii* infections accounted for 39.13% of gram-negative bacterial infections, which is similar to the result of sputum culture performed during the same period in our hospital. We believe these infections were nosocomial, possibly the result of poor hand hygiene during day-to-day care and contamination of the three-way tap of the infusion set. As a result, the bacteria entered the bloodstream via the three-way tap.

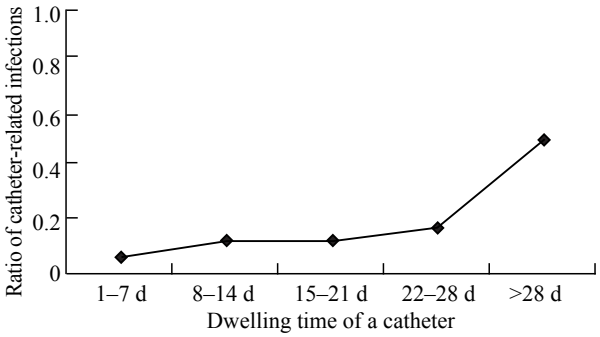

Figure 2. Ratio of catheter-related infections in different indwelling time of a catheter.

Risk factors for CRI

In this study, we carried out multivariate unconditional logistic regression analysis to determine the risk factors for CRI and our results showed that age, APACHE II score, femoral vein catheter placement, use of a multi-lumen catheter, repeated catheter placements, and long catheter indwelling time (>7 days) were independent risk factors for CRI.

Associations between CRI and age and APACHE II score

The average age of patients in this study was 65.3± 12.7 years, and most of them were older adults. Age is one of the risk factors for CRI. In recent years, a great proportion of patients in the ICU are elderly patients, and elderly patients have relatively poor physical condition, with more comorbidities than younger patients. The prevalence of malignant tumors and comorbidities

Table 1. Results of multivariate logistic regression analysis

Factors	β	S.E.	Wald χ^2	P	OR	95% CI
Age	0.915	0.186	24.072	<0.001	2.496	1.732–3.597
Gender	–0.167	0.188	0.785	0.376	0.846	0.585–1.224
Multicavity catheter	1.141	0.279	16.794	<0.001	3.131	1.814–5.405
APACHE II score	0.646	0.183	12.414	<0.001	1.908	1.332–2.734
Multiple catheterization	0.525	0.204	6.637	0.010	1.690	1.134–2.518
Long-term use of antibiotics	0.248	0.224	1.225	0.268	1.282	0.826–1.990
Femoral vein catheterization	0.511	0.219	5.443	0.020	1.666	1.085–2.559
Duration of catheterization (>7 days)	1.121	0.242	21.487	<0.001	3.067	1.910–4.927

such as diabetes is also high. Therefore, the risk of nosocomial infection is high in elderly patients.[8] In this study, the incidence of CRI in critically ill patients (APACHE II score >18 points) was significantly higher than that in other patients, which is consistent with the finding of other reports that critically ill patients have higher catheter infection rates than other patients.[1] In addition to their lower immunity, critically ill patients may also have greater use of venous catheters for manometry during rescue and greater use of rescue drugs during treatment. The end of the catheter is connected with many three-way taps in this setting, and frequent contact of healthcare workers with these three-way taps may increase the chance of contamination. Additionally, critically ill patients often require parenteral nutrition, and the carbohydrate and fat emulsion of this liquid makes it a very favorable medium for bacterial growth. The high solute content of parenteral nutrition emulsion makes it easily adhere to the catheter wall, leading to thrombosis or even blockage of the lumen and increasing the chance of bacterial infection. Mortality is increased in critically ill patients undergoing invasive examination and treatment measures such as deep venous catheter placement.[9] Siempos et al[10] carried out a meta-analysis in which they found that the mortality of patients increased significantly once catheter-related bloodstream infections occurred. Additionally, the severity scores of diseases in patients with catheter-related bloodstream infections were higher.

Association between CRI and femoral vein catheter and multi-lumen catheter

In this study, we found that the use of a femoral vein catheter was associated with a higher incidence of CRI. Factors related to this increased risk include the proximity of the femoral vein and the perineum, the high level of humidity in this area, the great number of bacterial colonies on the skin and the likelihood of the catheter being contaminated by excreta.[11] Therefore, we should try to avoid catheter placement via the femoral vein puncture to reduce the incidence of CRI. Application of multi-lumen catheters may increase the likelihood of infection in each chamber. Dobbins et al[12] reported 25 cases of CRI in patients with three-lumen catheters, and the catheter culture results showed a significantly increased probability of CRI when multi-lumen catheters were used.

Association between CRI and catheter indwelling time

Generally, fibrin deposition may appear 24 to 48 hours after catheter placement. A layer of loose fibrin sheath forms along the inside wall of the catheter, protecting the pathogenic microorganisms from phagocytosis and the action of anti-bacterial drugs. At the puncture site or the catheter connection, about 7 days are required for the pathogenic microorganisms to incubate. After that time, a large number of bacteria are released into the blood, causing bloodstream infection and symptoms. This study also showed that, with increased catheter indwelling time, the incidence of CRI showed an increasing trend. In particular, the incidence of CRI increased significantly when catheter indwelling time was greater than 7 days, which is consistent with other reports in China. Therefore, catheters should be changed within 7 days to reduce infection. To reduce the incidence of CRI, catheters should be removed as early as possible if catheter placement is not necessary.

Preventive measures for CRI

Currently, central venous catheters are undoubtedly an effective and irreplaceable treatment and monitoring tool in the field of critical care medicine. However, with their extensive application, related clinical complications have become increasingly prominent. In particular, CRI has become a very important research topic of nosocomial infection.

This study showed that age, use of a multi-lumen catheter, higher APACHE II score, repeated catheter placements, use of a femoral vein catheter, and long catheter indwelling time (>7 days) were independent risk factors for CRI. Therefore, medical staff should increase their knowledge about the risk factors for nosocomial infection. Other preventive measures include standardizing catheter placement procedures and developing a Central Line Bundle (CLB) prevention and treatment strategy to take into account the complications of central vein infection and risk factors for CRI. For example, hand hygiene should be strengthened, a maximum sterile barrier should be provided during catheter puncture, the skin should be disinfected with chlorhexidine, the most ideal site for catheter placement should be chosen and the need for catheter placement should be evaluated daily to minimize the incidence of CRI. Employing these strategies will reduce pain, medical costs, morbidity and mortality.[13–15] At the same time, appropriate use of central venous catheter should be encouraged to promote rapid recovery of patients.

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Ethical approval: The Institutional Review Board of Fujian

Provincial Hospital approved the study and waived the requirement for individual patient consent.

Conflicts of interest: The authors declare that there is no conflict of interest in this study.

Contributors: Chen M designed and developed the intellectual content of the manuscript including writing, review/editing and some statistical analysis. All authors contributed to the design and interpretation of the study and to further drafts.

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