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Major Article

Hospital-wide comparison of health care-associated infection among 8 intensive care units: A retrospective analysis for 2010-2015

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Pseudomonas aeruginosa

Background: Exploring the distribution of nosocomial pathogens among different categories of intensive care units (ICUs) is critical to improving the management of health care-associated infection (HAI). Despite both single- and multicenter studies, the nature of the variations of HAIs within various ICUs remains inadequately evaluated.

Methods: Data on HAIs at our hospital during the period January 2010-December 2015 were collected from 8 ICUs, namely, respiratory, cardiovascular, neurology, neonatal, hematology, emergency, cardiothoracic surgery, and neurosurgery ICUs, at a tertiary hospital.

Results: We observed a cumulative HAI incidence of 15.6/1,000 patient-days among 6,254 cases of infection at the hospital, as well as obvious interunit variations in HAI distribution. *Acinetobacter baumannii* was the leading organism of infection in almost every ICU, especially in emergency, neurosurgery, and neonatal ICUs. The most common pathogens were *Pseudomonas aeruginosa* in the cardiothoracic surgery, emergency, and neonatal ICUs; *Klebsiella pneumoniae* and *Escherichia coli* in the neurosurgery, emergency, neonatal, and neurology ICUs; and *Candida albicans* in both neurology and emergency ICUs.

Conclusions: Our findings revealed that *A baumannii and P aeruginosa* were the most common pathogens associated with invasive operations, whereas *K pneumoniae* and *E coli* were the most common pathogens in the medical ICUs.

Health care-associated infections (HAIs) are the leading preventable complications in critically ill patients and are associated with considerable morbidity and mortality.[1] The incidence of HAIs is approximately 4.5 for every 100 hospital admissions annually in developing countries, which places a heavy burden on the health care system.[2] Intensive care units (ICUs) at hospitals are associated with very high risk of acquiring HAI because of the poor overall health condition of patients and exposure to multiple medical interventions or invasive devices.[3] A survey of HAIs with feedback on acquired data to physicians or surgeons is fundamental to the development of effective strategies for reducing the risk of HAI in ICUs.[4,5]

A successful surveillance program is characterized by the application of epidemiologically sound definitions of infection, robust surveillance methods, and data feedback.[6] Many national-level surveys on HAIs have been initiated in the United States, Europe, and several developing countries to improve patient care and assist in clinical practice.[7,8] The comprehensive information obtained from these international and nationwide surveys have been effective in decreasing the incidence of all types of HAIs.[9] Unfortunately, the heterogeneity of data from facilities of different grades and the

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resultant differences in the survey models and reporting standards have undermined the clinical significance of these multicenter investigations. Moreover, summarized data only reflect the overall levels of HAI, and not the actual situation in individual institutions. This makes it impractical to initiate personalized interventions in individual hospitals based on these international survey data.

The nature of HAIs may substantially vary among different classes of ICUs owing to various factors such as the extent of invasiveness, site of intervention, and the patients' general condition. This makes it difficult to identify the key factors affecting the divergence in the HAI prevalence in different ICUs. Moreover, single-center HAI surveys have focused only on 1 ICU. Therefore, the distinctive hospital settings involved in the various studies have led to significant discrepancies among the findings of different surveys. In light of these considerations, it can be inferred that a unit-level HAI survey of different types of ICUs in a single hospital would eliminate various factors likely to bias the results and, thereby, significantly contribute to the currently available international surveillance data.[10] A computerized search using key words such as *ICU* and *HAI* or *nosocomial infection* for entries made in journal databases (eg, PubMed) retrieved very few reports comparing the HAI prevalence among different types of ICUs at a single institution. In particular, there were no reports about the HAIs from any single institution in China. Therefore, a comprehensive study of the prevalence in different types of ICUs at a single institution would be beneficial to prevent HAIs and reduce the economic burden on patients and hospitals.

Southwest Hospital is among the largest tertiary teaching hospitals in Chongqing, China. Since 2010, this hospital has had a comprehensive intensive care system comprising 8 ICUs, including 1 neonatal, 4 medical, and 3 surgical ICUs. The intensive care system provides abundant facilities for patients who need intensive care and facilitates an effective HAI surveillance accompanied by a well-developed and hospital-wide network service. Unlike traditional multicenter-based surveillance, a single hospital-based surveillance, by virtue of its uniform nature, would enable reliable assessment of HAIs. By conducting a retrospective analysis of HAI on surveillance data retrieved from the intensive care system for the period 2010-2015, we attempt to answer the following questions: What is the prevalence of HAI in a multispecialty hospital? And, What is the epidemiology of HAI in each ICU from a single hospital?

METHODS

Study design

This study was designed as a retrospective cohort study of the survey data maintained at the Southwest Hospital affiliated with the Third Military Medical University for the period January 2010-December 2015. Data from various laboratory tests were obtained, including blood, sputum, cerebrospinal fluid, endotracheal tube aspirates, peritoneal fluid, stool, urine, and other tests. All patient records were anonymized and de-identified before the start of the analysis. The protocol of this study was approved by the Ethics Committee of Southwest Hospital affiliated to the Third Military Medical University.

Study setting

Southwest Hospital is a tertiary teaching hospital in Chongqing municipality with 2,900 beds and 8 ICUs; these include the respiratory, cardiovascular, neurology, neonatal, hematology, comprehensive, cardiothoracic surgery, and neurosurgery ICUs. Furthermore, the 8 ICUs are also classified according to treatment types: medicine (respiratory, cardiovascular, neurology, neonatal, and hematology) and surgery (emergency, cardiothoracic surgery, and neurosurgery) ICUs. To determine whether HAIs in the neonatal ICU (NICU) differ from those in other ICUs, we also categorized the ICUs into NICU (n = 1) and adult ICUs (n = 7).

Only patients who remained in the ICU for at least 48 hours were enrolled in this study.[11] Laboratory tests were performed using standard procedures only if clinical symptoms were present. Microorganisms were cultured in a medical microbiology laboratory with International Organization for Standardization 15189 accreditation. The cultures were treated according to Clinical and Laboratory Standards Institute guidelines.

HAI was defined according to the recommendations of the Centers for Disease Control and Prevention.[12] To gain a better understanding of these major causative microorganisms, only 5 of the most common bacteria in each ICU were identified. The gram-positive bacteria were *Staphylococcus aureus*, coagulase-negative staphylococci (CoNS), and others. CoNS infection was diagnosed if the culture results of 2 blood samples collected on different days 1 month apart were both positive for the same species.[13] In these cases, the date of the first sample collection was regarded as the date of colonization.

Infections that occurred at least 48 hours after admission were regarded as nosocomial. For patients who were referred from another hospital, infections that occurred within 48 hours after admission were considered to have been acquired at the previous hospital.[14] In addition, infections that occurred in the following situations were excluded: infection associated with a complication or extension of infection already detected on admission, unless changes in pathogens or symptoms strongly suggested the acquisition of a new infection; in the case of infants, an infection acquired transplacentally (eg, toxoplasmosis, rubella, cytomegalovirus, or syphilis) and within 48 hours after birth. The same organism isolated repeatedly from the same patient within 1 episode of hospitalization was counted as 1.

The HAI incidence (total number of HAIs/1,000 patient-days) was employed to estimate infection rates according to the recommendations of the Centers for Disease Control and Prevention.[12] The frequency of each HAI (number of times a given organism was isolated/total number of isolated organisms) was calculated to compare the epidemiology of microorganisms in different ICUs.

Statistical analysis

The retrieved data were analyzed using SPSS software version 20.0 (IBM China Co Ltd, Beijing, China). A χ^2 test (level of significance $P < .05$) was used to compare the incidence of HAI in the ICUs.

RESULTS

Characteristics of patients with infections from 2010-2015

As shown in Table 1, we found that 5,411 patients admitted to the 8 ICUs developed HAIs, with 6,254 positive isolates being collected over the 5-year period between 2010 and 2015. Among these positive isolates, the sputum samples were dominant (76.56% of all positive samples), with the other samples, including urine (7.34%), blood (4.02%), stool (3.48%), cerebrospinal fluid (3.64%), endotracheal tube aspirates (2.23%), peritoneal fluid (1.03%), and others (1.76%), accounting for only 23.5% of the positive isolates. Moreover, the ratio of the number of infections to patient-days was 2.41% for the entire 5-year period. Although gender did not contribute to the susceptibility of HAIs in ICUs ($P = .198$), male patients tended to be more susceptible to infections than female patients in the surgical ICUs ($P = .076$) (Table 1). Furthermore, the percentages of