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ORIGINAL ARTICLE

Selection of empirical antibiotics for health care-associated pneumonia via integration of pneumonia severity index and risk factors of drug-resistant pathogens

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Background/purpose: The pneumonia severity index (PSI) both contains some risk factors of drug-resistant pathogens (DRPs) and represents the severity of health care-associated pneumonia. The aim of this study was to investigate whether the PSI could be used to predict DRPs and whether there were risk factors beyond the PSI.
Methods: A retrospective observational study enrolled 530 patients with health care-associated pneumonia who were admitted from January 2005 to December 2010 in a tertiary care hospital.
Results: A total of 206 patients (38.9%) had DRPs, of which the most common was *Pseudomonas aeruginosa* (24.3%). The incidence of DRPs increased with increasing PSI classes (6.7%, 25.5%, 36.9%, and 44.6% in PSI II, III, IV, and V, respectively). An analysis of the risk factors for DRPs by PSI classes revealed that wound care was associated with methicillin-resistant *Staphylococcus aureus* (MRSA) infection in PSI V ($p = 0.045$). Nasogastric tube feeding (odds ratio, 3.88; 95% confidence interval, 1.75–8.60; $p = 0.006$), and bronchiectasis (odds ratio, 3.12; 95% confidence interval, 0.66–14.69; $p = 0.007$) were risk factors for DRPs in PSI III and IV. The area under the receiver operating characteristic curve progressed from 0.578 to 0.651 while integrating these risk factors with PSI classes.
Conclusion: The findings suggested that PSI plus risk factors predicted the risk of DRPs. PSI II had a low risk of DRPs and could be treated as community-acquired pneumonia. Antibiotics

Conflicts of interests: The authors have no conflicts of interest relevant to this article.

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of PSI III and IV with risk factors could be targeted DRPs. PSI V with wound care had a higher risk of MRSA, and empirical anti-MRSA antibiotics could be added.
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Introduction

Obtaining microbiological information as quickly as possible remains a challenge when treating patients with pneumonia. Pneumonia is classified as community-acquired pneumonia (CAP) and hospital-acquired pneumonia (HAP), which suggests the possible pathogens and therefore the choice of antibiotics in the early phase of the treatment for pneumonia.[1,2] However, several studies have reported that some CAP patients are at a greater risk of gram-negative bacteria and pathogens resistant to conventional CAP antibiotics.[3–5] The 2005 American Thoracic Society/Infectious Disease Society of America (ATS/IDSA) guidelines first defined the subgroup of CAP as health care-associated pneumonia (HCAP), and recommended broad-spectrum antibiotics similar to those used for HAP.[6] However, some studies do not suggest the use of empirical broad-spectrum antibiotics because HCAP is actually a heterogeneous group.[7] Predicting the occurrence of drug-resistant pathogens (DRPs) at diagnosis is one of the most important issues in patients with HCAP, thereby avoiding inadequate or overuse of broad-spectrum antibiotics. Several risk factors for DRPs in HCAP, including hospitalization in the past 90 days, recent antibiotic therapy in the past 6 months, poor functional status, and immune suppression, have been reported.[7–10]

According to the 2005 ATS/IDSA guidelines for HAP, ventilator-associated pneumonia, and HCAP, the selection of empirical antibiotics should take into consideration the risk factors for DRPs, but not include the severity of the patient's disease.[6] However, according to studies of CAP, stratification of the severity of disease can guide decisions on the site of care and also the selection of antibiotics.[11,12] Therefore, we hypothesized that the severity of HCAP would be correlated with DRPs. However, there are currently no well-accepted methods to evaluate the severity of HCAP. Some investigators have shown that predictive scoring systems, such as the pneumonia severity index (PSI) or CURB-65, can also be used with HCAP.[13,14] Because risk factors suggestive of DRPs[10,15] overlap with some items of the PSI, we planned to use the PSI to evaluate the severity of HCAP. We conducted this retrospective observational study at a tertiary care hospital. The primary end-point was the correlation between PSI and DRPs. The secondary end-point was to identify whether there were additional risk factors for DRPs beyond the PSI.

Materials and methods

Patients who were admitted to our 800-bed tertiary care hospital in Taiwan, from January 2005 to December 2010, were screened by discharge diagnosis. The medical records of the patients whose primary discharge diagnosis was pneumonia (International Classification of Diseases codes 482, 485, and 486) were reviewed. The patients were enrolled if they fulfilled the criteria for HCAP,[6] which were defined as follows: patients who had been hospitalized in an acute care hospital for $\geq$ 2 days within the past 90 days; residents of a nursing home or long-term care facility; recipients of recent intravenous antibiotic therapy, chemotherapy or wound care within the past 30 days; or patients who attended a hospital or hemodialysis clinic. Because of the uncertain clinical course, the patients who had been transferred from other hospitals after hospitalization were excluded. The Institutional Review Board of the Far Eastern Memorial Hospital, New Taipei City, Taiwan approved this study (IRB 102013-E).

The definition of steroid use was a daily steroid dose of $>$ 10 mg lasting for $>$ 3 months. Chronic kidney disease was defined as an estimated glomerular filtration rate $<$ 30 mL/min without the need for hemodialysis. Chemotherapy was defined as having undergone chemotherapy within 60 days for a malignancy. Although arterial blood gas data were not available in some patients, arterial partial pressure of oxygen was considered to be $<$ 60 mmHg if oxygen saturation measured by pulse oximetry was $<$ 90% in room air. The data on causative pathogens were obtained from sputum cultures and/or the cultures of sterile specimens within 24 hours after the diagnosis of pneumonia had been established, e.g., from blood or pleural effusion. The data of sputum culture were reported in a semiquantitative manner. Possible causative pathogens were identified from sputum if the collected sputum samples were of sufficient quality, defined as $>$ 25 polymorphonuclear cells and $<$ 10 epithelial cells per power field with a total magnification $\times$ 100, and a moderate or heavy amount of growth in the cultures. DRPs were defined as those not sensitive to the antibiotics suggested for CAP treatment, such as β-lactam, macrolide, and respiratory fluoroquinolones.[12] The initial antibiotic treatment was classified as being inappropriate if the initially prescribed antibiotics were not active against the identified pathogens based on *in vitro* susceptibility testing.[15] Antibiotics against *Pseudomonas aeruginosa* and methicillin-resistant *Staphylococcus aureus* (MRSA) were defined as the broad-spectrum antibiotics. PSI scores and grouping were calculated according to the principles of the Pneumonia Patient Outcomes Research Team cohort study on CAP.[16] PSI is based on age and the presence of coexisting disease including neoplastic disease, liver disease, renal disease, cerebrovascular disease, and congestive heart failure, abnormal physical findings (such as respiratory rate, body temperature, pulse, blood pressure), and mental status as well as abnormal laboratory and radiographic findings (blood pH, urea nitrogen concentration, blood sugar,

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