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Nosocomial pneumonia in non-invasive ventilation patients: incidence, characteristics, and outcomes

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SUMMARY

Background: Nosocomial pneumonia occasionally occurs in non-invasive ventilation (NIV) patients.

Aim: To report the incidence, characteristics, and outcomes of nosocomial pneumonia in NIV patients.

Methods: A prospective observational study was performed in a respiratory intensive care unit (ICU). After admission, patients who received NIV for more than 48 h were enrolled. Pneumonia was considered nosocomial when it occurred after at least 48 h of NIV.

Findings: Between January 2012 and August 2014, we enrolled 520 NIV patients. Nosocomial pneumonia occurred in 16 patients (3.1%). The nosocomial pneumonia rate was 4.5 cases per 1000 NIV-days. The most common pathogen was *Acinetobacter baumannii* (81%). At the initiation of NIV, there were no differences in age, gender, diagnosis, disease severity, or arterial blood gas findings between patients with and without nosocomial pneumonia. Compared to patients without nosocomial pneumonia, nosocomial pneumonia patients had a longer duration of NIV (8.4 vs 5.0 days, $P < 0.01$), a longer ICU stay (10.8 vs 7.9 days, $P = 0.01$), a longer hospital stay (25.9 vs 15.3 days, $P = 0.04$), a higher intubation rate (63% vs 21%, $P < 0.01$), and higher hospital mortality (75% vs 25%, $P < 0.01$). Nosocomial pneumonia was an independent risk factor for intubation (OR: 6.74; 95% CI: 2.24–20.28) and death (7.65; 1.34–43.72).

Conclusion: The incidence of nosocomial pneumonia in NIV patients in this population was 3.1%. Nosocomial pneumonia increased the time that NIV was required, length of ICU stay, length of hospital stay, intubation rate, and hospital mortality.

Introduction

Nosocomial pneumonia is one of the most common nosocomial infections in hospitalized patients, with a reported incidence of 0.85% of all hospitalized patients.[1] The incidence rises in higher-risk groups, to 1.83% medical intensive care unit (ICU) patients and to 2.01% in surgical ICU patients.[2] Additionally, nosocomial pneumonia has been reported to increase the average hospital cost by US$4,200; in two other studies, it increased hospital mortality by 1.6-fold and hospital stay by 14 days.[3–5] Because of the poorer outcomes in patients with nosocomial pneumonia, guidelines have been developed to prevent nosocomial pneumonia and manage it when it does occur.[6–8]

Non-invasive ventilation (NIV) has been recommended to prevent nosocomial pneumonia in critically ill patients.[9]

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Compared with invasive mechanical ventilation, NIV reduced nosocomial pneumonia, shortened the required duration of invasive mechanical ventilation, and lowered hospital mortality.[10] However, nosocomial pneumonia still occurs in NIV patients.[11] To date, the incidence, characteristics, and outcomes of nosocomial pneumonia in NIV patients have not been reported in detail.

Methods

This study was performed in a respiratory ICU from January 2012 to August 2014. It was approved by the investigational review board of The First Affiliated Hospital of Chongqing Medical University. Because no intervention was examined in this study, the requirement for written informed consent was waived. All respiratory failure patients admitted to our ICU for NIV were considered for inclusion in this study. If the patient received NIV for more than two days, he or she was enrolled in the study. However, patients aged <18 years and patients with a 'do not intubate' order were excluded from participation.

Management of NIV

The NIV was managed by our attending physicians, respiratory therapists, and nurses. An oronasal mask interface (ZS-MZ-A Face Mask; Shanghai Zhongshan Medical Technology Co., Shanghai, China) was the first choice for NIV treatment. Mask size was based on the patient's facial type. A humidifier with a thermometer was used throughout NIV. The temperature was selected based on the patient's comfort, tolerance, and adherence but was kept at <41°C.[12] Sterile water was added intermittently to the humidifier based on the water level of the humidifier. Additionally, oral fluids were allowed intermittently if the patient's mouth and nose were dry. To prevent skin breakdown and excessive air leakage, air leakage was kept to <30 L/min, and the straps were kept as tight as possible while remaining comfortable for the patient. Patients were positioned at 30° to 45° to avoid aspiration, assuming there were no contraindications to this positioning. A disposable bacterial filter was placed between the circuit and the ventilator and was changed every day. The water trap of the circuit was kept at the lowest possible level to collect condensed water. The disposable circuit of the NIV was changed every seven days and when it was visibly soiled or malfunctioned. The initiation modes were continuous positive airway pressure (CPAP) or spontaneous/time (S/T) mode (BiPAP Vision or Respironics V60). For patients with hypoaemia or heart failure, CPAP was used as the initiation mode. Patients with hypercapnia or vigorous activity of accessory respiratory muscles were initiated in S/T mode. Initially, continuous use of NIV was encouraged. Once respiratory failure was relieved, NIV was used intermittently until the patient could be completely weaned from it.

Intubation was performed if respiratory failure worsened, as determined by the presence of one major criterion, or two or more minor criteria.[13] Major criteria were: (i) respiratory arrest, (ii) loss of consciousness, (iii) haemodynamic instability, (iv) inability to correct dyspnoea, and (v) arterial partial pressure of oxygen (PaO_2)/fraction of inspired oxygen (FiO_2) <100 mmHg. Minor criteria were: (i) respiratory rate >35 breaths/min, (ii) blood pH <7.30, (iii) persistent tachypnoea, (iv) persistent activation of accessory respiratory muscles, and (v) PaO_2/FiO_2 <200 mmHg.

Prevention of nosocomial infection

All staff complied with hospital protocols to prevent nosocomial infection. Any personnel who were new to the ICU were taught these protocols. The managers of nosocomial infection in the ICU covertly monitored staff compliance with the protocols twice per week, and furnished reminders to any staff who did not comply with these protocols. Reusable equipment included the non-invasive ventilator, which was sterilized upon termination of treatment. Before and after each visit, staff washed their hands under running water and dried their hands with disposable towels, or used a hand gel disinfectant. Prior to any patient contact, such as a physical examination, disposable non-sterile gloves were used. If a nosocomial infection occurred, the patient was isolated. Isolation gowns were used for all visits, including those from family members. These detailed protocols were based on suggestions from the World Health Organization.[14]

Diagnosis and treatment of nosocomial pneumonia

Nosocomial pneumonia was suspected if a patient had a radiographic infiltrate that was new or progressive, along with clinical findings suggesting infection, including new onset of fever, purulent sputum, leukocytosis, and decline in oxygenation. In patients with suspected pneumonia, respiratory tract culture was performed once per day for three consecutive days. Samples were obtained by coughing, nasotracheal suction, a protected specimen brush, or bronchoalveolar lavage. Nosocomial pneumonia was confirmed by a positive culture. Antibiotics were selected and administered according to the local prescribing policy, which included guidance on choice of agent, dose, and route of administration.[6]

Statistical analysis

Data were analysed by statistical software (SPSS 17.0, SPSS, Chicago, IL, USA). Normally distributed continuous variables were analysed with the unpaired Student's *t*-test. Abnormally distributed continuous variables were analysed with the Mann–Whitney *U*-test. Categorical variables were analysed by the chi-square or Fisher exact test when appropriate. Kaplan–Meier curves were used to analyse the proportions of patients remaining on NIV and remaining in the ICU among those with and without nosocomial pneumonia. Independent risk factors of intubation or death were identified by multivariable logistic regression analysis. $P < 0.05$ was considered significant.

Results

The incidence of nosocomial pneumonia in NIV patients was 3.1% (Table I), or 4.5 per 1000 NIV-days. Upon initiation of NIV, there were no statistically significant differences in age, gender, diagnosis, Acute Physiology and Chronic Health Evaluation II score, systolic blood pressure, diastolic blood pressure, heart rate, respiratory rate, pH, $PaCO_2$, and PaO_2/FiO_2 between patients who subsequently did and did not develop nosocomial pneumonia (Table I).