Original Article

Ventilator-Associated Pneumonia: Epidemiology and Prognostic Indicators of 30-Day Mortality

Juthamas Inchai1, Chaicharn Pothirat1*, Chalerm Liwsrisakun1, Athavudh Deesomchoke1, Weerayut Kositsakulchai3, and Nipon Chalermpanchan1

1Division of Pulmonary, Critical Care and Allergy, Department of Internal Medicine, Faculty of Medicine, Chiang Mai University, Chiang Mai; 2Department of Medicine, Nakornping Hospital, Chiang Mai; and 3Department of Medicine, Lampang Hospital, Lampang, Thailand

SUMMARY: We conducted a retrospective cohort study in the medical intensive care unit of Chiang Mai University Hospital to describe the epidemiology of ventilator-associated pneumonia (VAP) and identify prognostic indicators of 30-day VAP mortality. A total of 621 patients diagnosed with VAP between January 2005 and December 2011 were included. The overall 30-day mortality rate was 44.4%. The major causative pathogens were Acinetobacter baumannii (54.3%), Pseudomonas aeruginosa (35.2%), and methicillin-resistant Staphylococcus aureus (15.1%). Most A. baumannii (90.2%) comprised drug-resistant strains. Identified prognostic indicators were co-morbid malignancy (hazard ratio [HR] = 1.60; 95% confidence interval [CI] 1.02–2.42; P = 0.040), septic shock (HR = 2.51; 95% CI, 1.60–4.00; P < 0.001), Simplified Acute Physiology Score II > 45 (HR = 1.62; 95% CI, 1.03–2.56; P = 0.041), Sequential Organ Failure Assessment score > 5 (HR = 3.40; 95% CI 2.00–5.81; P < 0.001), and delayed inappropriate empirical antibiotic treatment (HR = 2.23; 95% CI, 1.12–4.45; P = 0.022). VAP was associated with high mortality. The major causative pathogen was drug-resistant A. baumannii. Therefore, early detection of VAP by surveillance in mechanically ventilated patients leading to earlier treatment may improve patient outcomes. Guidelines for prescribing appropriate empirical antibiota to cover drug-resistant bacteria could be established using local epidemiological data.

INTRODUCTION

Ventilator-associated pneumonia (VAP) is associated with poor outcomes, including morbidity and mortality, and results in prolonged hospital stays and increased economic burden among critically ill patients. The mortality rate of VAP varies from 25% to 45% and has been found to be greater when caused by antibiotic-resistant pathogens (1–4). Recent studies have demonstrated increasing incidences of antibiotic-resistant bacteria causing VAP, particularly Acinetobacter baumannii, in intensive care units (ICU) in a number of countries (4–6). Unfortunately, epidemiological data and knowledge of VAP prognostic factors in Thailand is lacking, particularly from medical ICU cases. The aim of this study was to investigate the epidemiology of VAP and identify prognostic indicators of 30-day VAP mortality in a tertiary center of Thailand.

MATERIALS AND METHODS

A retrospective cohort study was conducted in the 40-bed medical ICU of the 1,400-bed Chiang Mai University Hospital, Chiang Mai, Thailand. All included patients were adults diagnosed with VAP according to 2005 ATS/IDSA criteria (1) from January 2005 through December 2011. The study was approved by the Ethics Committee of the Faculty of Medicine, Chiang Mai University.

Participants: All medical ICU patients with VAP and available records in the ICU Infection Control database from 2005 to 2011 were retrospectively reviewed. VAP is defined as a new or progressive pulmonary infiltration occurring more than 48 h after endotracheal intubation in combination with at least 2 of the following criteria: temperature > 38.3°C or < 36.0°C; change in character of sputum (purulent or increased amount of sputum); white blood cell count > 12,000 or < 4,000 cells/mm³. VAP is further classified into early-onset VAP, occurring within 4 days of endotracheal intubation, and late-onset VAP, developing more than 4 days after endotracheal intubation. Cases of community-acquired pneumonia, non-mechanical ventilated hospital-acquired pneumonia, and healthcare-associated pneumonia were excluded.

Respiratory samples were obtained from either tracheal aspirates or bronchoalveolar lavage. Quantitative culture cut-off points of > 10⁶ CFU/ml and > 10⁴ CFU/ml were used for the diagnosis of bacterial VAP. Isolated bacterial sensitivities were determined using the disk diffusion method, as recommended by the Clinical and Laboratory Standards Institute.

Data collection: Demographic data for all VAP patients, including clinical pulmonary infection score (CPIS), were collected. Sepsis status at VAP onset was...
classified as sepsis, severe sepsis, or septic shock, according to the 2012 Surviving Sepsis Campaign (7). Severity assessment scores, including the Simplified Acute Physiology Score (SAPS II) and the Sequential Organ Failure Assessment (SOFA) score, were used from the time of VAP on set. Causative pathogens were recorded. When *A. baumannii* was identified as the cause of VAP, strains were identified according to sensitivity pattern: drug sensitive, multi-drug resistant (MDR), extensive-drug resistant (XDR), or pan-drug resistant (PDR). MDR-*A. baumannii* was defined as acquired resistance to at least 3 classes of the following antibiotics: all cephalosporins, aminoglycosides, fluoroquinolones, carbapenems, and beta-lactam/beta-lactamase inhibitors. XDR-*A. baumannii* was defined as resistance to all standard antimicrobial agents except polymyxin-B and tigecycline. PDR *A. baumannii* was defined as resistance to all categories of antimicrobial agents (8). The appropriateness of initial empirical antimicrobial treatment was assessed according to whether the causative agents were sensitive or resistant to antibiotics prescribed. Time to initiation of antibiotics was classified as either early or late according to whether empirical antibiotics were administered within 24 h or after 24 h of VAP onset, respectively. We also monitored both ICU and hospital discharge status.

All patients were followed up for survival status until 30 days after initial onset of VAP or until death (if patients died within 30 days). The overall 30-day mortality and time between VAP onset and death were recorded.

**Statistical analysis:** Patient data were compared between the survivor and non-survivor groups. Categorical variables were expressed as count and percentage and analyzed using the Fisher’s exact test. Continuous variables were expressed as mean and standard deviation or median and interquartile range, and analyzed using Student’s t-test or the Wilcoxon rank-sum test. Univariate and multivariate Cox’s proportional hazard regression analysis was performed to identify prognostic indicators of 30-day mortality. Each variable with a *P*-value < 0.05 in the univariate analysis was considered a prognostic indicator and further analyzed using multivariate models to identify independent prognostic indicators. A *P*-value < 0.05 was considered statistically significant. All statistical analyses were performed using STATA version 11 (StataCorp LP, College Station, TX, USA).

**RESULTS**

**Epidemiology:** A total of 621 VAP patients were enrolled in this study; 98.4% of cases were first episodes of VAP. Epidemiological data are shown in Tables 1 and 2. A total of 333 (53.6%) males and 288 (46.4%) females with a mean age of 62.2 ± 18.1 years (range 15–99 years) were included. Late-onset VAP was observed in 85.3% of patients. The median duration of hospitalization and mechanical ventilation prior to VAP onset was 10 and 9 days, respectively. The mean CPIS was 8.1 ± 1.3. The mean SAPS II and SOFA scores were 46.3 ± 14.2 and 6.6 ± 2.7, respectively. The overall 30-day, ICU, and in-hospital mortality rates (MR) were 44.4%, 29.0%, and 50.9%, respectively. *A. baumannii* was defined as the leading cause of VAP (54.3%), followed by *Pseudomonas aeruginosa* (35.2%) and MRSA (15.1%). The distribution of *A. baumannii* sensitivity patterns was 9.8% drug sensitive, 21.4% MDR, 65.3% XDR, and 3.6% PDR. Although the number of the patients receiving early and appropriate antibiotic treatment was 363 (59.3%), the rate of early but inappropriate treatment was high at 31.5% (Tables 2 and 3). The most frequently initially administered antibiotics were colistin (33.2%) and carbapenem (27.0%). The mean duration of antibiotic treatment was 12.62 ± 5.7 days.

**Prognostic indicators:** The total number of patients in the survivor and non-survivor groups was 345 and 276, respectively. The clinical characteristics of survivors and non-survivors are shown in Tables 1 and 2. Baseline characteristics between the 2 groups including sex, age, duration of hospitalization before VAP onset and comorbidities with chronic obstructive pulmonary disease (COPD), cardiovascular disease, cerebrovascular accident, and diabetes mellitus were not statistically significant.

The following factors were found to be significantly

---

**Table 1. Demographic data of VAP patients compared between survivor and non-survivor group**

| Variable                        | All case *(n = 621)* | Survivor *(n = 345)* | Non-survivor *(n = 276)* | *p*  |
|---------------------------------|----------------------|----------------------|--------------------------|------|
| **Gender:** Male, n (%)         | 333 (53.6)           | 181 (52.5)           | 151 (55)                 | 0.571|
| Age (yrs.) (range)              | 62.2 ± 18.1 (15-99)  | 61.0 ± 19.5 (15-99)  | 63.6 ± 16.0 (16-96)      | 0.075|
| Co-morbidity, n (%)             |                      |                      |                          |      |
| — Renal diseases                | 196 (31.6)           | 95 (27.5)            | 101 (36.6)               | 0.016|
| — Cerebrovascular diseases      | 181 (29.2)           | 111 (32.2)           | 70 (25.4)                | 0.063|
| — Cardiovascular diseases       | 178 (28.7)           | 102 (29.6)           | 76 (27.5)                | 0.574|
| — COPD                          | 99 (15.9)            | 57 (16.5)            | 42 (15.2)                | 0.659|
| — Diabetes mellitus             | 98 (15.8)            | 49 (14.2)            | 49 (17.8)                | 0.234|
| — Immunocompromised states 1)   | 100 (16.1)           | 40 (11.6)            | 60 (21.7)                | 0.001|
| — Malignancy                    | 77 (12.4)            | 25 (7.2)             | 52 (18.9)                | <0.001|
| — Hematologic diseases          | 35 (5.6)             | 11 (3.2)             | 24 (8.7)                 | 0.003|
| — Hepatic diseases              | 53 (8.9)             | 22 (6.4)             | 31 (11.2)                | 0.031|

1): SLE, HIV/AIDS, and immunosuppressant drug. COPD, chronic obstructive pulmonary disease.
Table 2. Clinical characteristics of VAP patients compared between survivor and non-survivor group and mortality rate

| Variable                              | All case (n = 621) | Survivor (n = 345) | Non-survivor (n = 276) | P     |
|---------------------------------------|--------------------|--------------------|------------------------|-------|
| **VAP onset**                         |                    |                    |                        |       |
| — Early                               | 90 (14.7)          | 59 (17.3)          | 31 (11.4)              | 0.038 |
| — Late                                | 524 (85.3)         | 282 (82.7)         | 242 (88.6)             |       |
| **CXR: extents of infiltration, n (%)**|                    |                    |                        |       |
| — Single lobe                         | 560 (90.2)         | 320 (92.8)         | 240 (87.0)             | 0.016 |
| — Multi-lobes                         | 61 (9.8)           | 25 (7.2)           | 36 (13.0)              |       |
| **CPIS**                              | Mean ± SD (range)  |                    |                        |       |
|                                       | 8.1 ± 1.3 (6–14)   | 7.9 ± 1.1 (6–12)   | 8.4 ± 1.4 (6–14)       | <0.001|
| **Sepsis status, n (%)**              |                    |                    |                        |       |
| — Severe sepsis                       | 347 (55.9)         | 285 (82.6)         | 62 (22.5)              | <0.001|
| — Septic shock                        | 274 (44.1)         | 60 (17.4)          | 262 (77.5)             |       |
| **Severity score**                    |                    |                    |                        |       |
| SAPS II                               | Mean ± SD (range)  |                    |                        |       |
|                                       | 46.3 ± 14.2 (6–92) | 39.8 ± 11.5 (6–80)| 54.5 ± 12.8 (18–92)   | <0.001|
| SOFA                                  | Mean ± SD (range)  |                    |                        |       |
|                                       | 6.6 ± 2.7 (2–18)   | 5.4 ± 2.2 (2–16)   | 8.3 ± 2.4 (3–18)       | <0.001|
| **Admission day before VAP onset (day)** |                |                    |                        |       |
| Median (IQR)                          | 10 (6, 20)         | 9 (6, 19)          | 11 (6, 23)             | 0.077 |
| MV day before VAP onset (day)         |                    |                    |                        |       |
| Median (IQR)                          | 9 (5, 15)          | 9 (5, 14)          | 10 (6, 19)             | 0.024 |

MV, mechanical ventilator.

Table 3. Pathogens and antibiotic treatment of VAP patients compared between survivor and non-survivor group

| Variable                              | All case (n = 621) | Survivor (n = 345) | Non-survivor (n = 276) | P     |
|---------------------------------------|--------------------|--------------------|------------------------|-------|
| **Pathogens, n (%)**                  |                    |                    |                        |       |
| — Single microbial                    | 411 (66.5)         | 222 (64.9)         | 189 (68.5)             | 0.350 |
| — Poly-microbials                     | 207 (33.5)         | 120 (35.1)         | 87 (31.5)              |       |
| **Pathogens species, n (%)**          |                    |                    |                        |       |
| — A. baumannii                        | 337 (54.3)         | 174 (50.3)         | 163 (59.1)             | <0.001|
|                                      | Drug-sensitive     | 33 (9.8)           | 26 (14.9)              | 7 (4.3)|
|                                      | MDR                | 72 (21.4)          | 49 (28.2)              | 23 (14.1)|
|                                      | XDR                | 220 (65.3)         | 95 (54.6)              | 125 (76.7)|
|                                      | PDR                | 12 (3.6)           | 4 (2.3)                | 8 (4.9)|
| — P. aeruginosa                       | 191 (35.2)         | 112 (32.6)         | 79 (28.6)              | 0.292 |
| — MRSA                               | 94 (15.1)          | 50 (14.5)          | 44 (16.0)              | 0.617 |
| — K. pneumoniae                       | 67 (10.8)          | 37 (10.7)          | 30 (11.0)              | 0.954 |
| — Others                              | 118 (19.0)         | 73 (21.2)          | 45 (16.3)              | 0.125 |
| **Empirical antibiotic treatment, n (%)** |                |                    |                        |       |
| — Single antibiotic                   | 246 (39.6)         | 144 (49.3)         | 91 (42.1)              | 0.108 |
| — Combined antibiotics                | 286 (46.5)         | 148 (50.7)         | 125 (57.9)             |       |
| **Time to start antibiotic**          |                    |                    |                        |       |
| — Early                               | 556 (90.8)         | 316 (92.7)         | 240 (88.6)             | 0.080 |
| — Late                                | 56 (9.2)           | 25 (7.3)           | 31 (11.4)              |       |
| ** Appropriateness of antibiotic treatment, n (%)** | | | | |
| — Appropriate                         | 398 (64.6)         | 251 (73.4)         | 147 (53.6)             | <0.001|
| — Inappropriate                       | 218 (35.4)         | 91 (26.6)          | 127 (46.4)             |       |
| **Group of Initial antibiotic Treatment, n (%)** | | | | |
| — Early & appropriate                 | 363 (59.3)         | 237 (69.5)         | 126 (46.5)             | <0.001|
| — Early & inappropriate               | 193 (31.5)         | 79 (23.2)          | 114 (42.1)             |       |
| — Late & appropriate                  | 30 (4.9)           | 15 (4.4)           | 15 (5.5)               |       |
| — Late & inappropriate                | 26 (4.2)           | 10 (2.9)           | 16 (5.9)               |       |

*: E. coli, S. maltophilia, H. influenzae, Enterobacter spp., Proteus spp., MSSA, Enterococcus spp.
MDR, multi-drug resistant; XDR, extensive-drug resistant; PDR, pan-drug resistant A. baumannii.
associated with increased 30-day mortality by univariate analysis: malignancy (hazard ratio [HR] = 2.14; 95% confidence interval [CI] = 1.60–2.90; P = 0.001); renal disease (HR = 1.31; 95% CI, 1.02–1.67; P = 0.029); immunocompromised status (HR = 1.75; 95% CI, 1.31–2.33; P < 0.001); hematologic disease (HR = 1.95; 95% CI, 1.28–2.96; P = 0.002); hepatic diseases (HR = 1.69; 95% CI, 1.17–2.45; P = 0.005).

Table 4. Prognostic indicators of mortality in VAP patients by using univariate Cox’s proportional hazards regression analysis

| Predictor                          | HR     | 95% CI   | P     |
|-----------------------------------|--------|----------|-------|
| Male gender                       | 1.07   | 0.84–1.35| 0.612 |
| Age > 60 years                    | 1.15   | 0.91–1.50| 0.208 |
| Co-morbidity                      |        |          |       |
| — Renal diseases                  | 1.31   | 1.02–1.67| 0.029 |
| — Cerebrovascular diseases        | 0.77   | 0.58–1.01| 0.064 |
| — Cardiovascular diseases         | 0.91   | 0.70–1.88| 0.470 |
| — COPD                            | 0.92   | 0.67–1.28| 0.442 |
| — DM                              | 1.19   | 0.88–1.63| 0.250 |
| — Immunocompromised states        | 1.75   | 1.31–2.33| <0.001|
| — Malignancy                      | 2.14   | 1.60–2.90| <0.001|
| — Hematologic diseases            | 1.95   | 1.28–2.96| 0.002 |
| — Hepatic diseases                | 1.69   | 1.17–2.45| 0.005 |
| VAP onset                         |        |          |       |
| — Early                           | 1.03   | 0.98–2.09| 0.064 |
| — Late                            | 1.50   | 1.04–2.10| 0.031 |
| CXR: extents of infiltration      |        |          |       |
| — Single lobe                     | 1.40   | 0.97–1.96| 0.072 |
| — Multi-lobes                     | 4.80   | 3.75–6.14| <0.001|
| Sepsis status                     |        |          |       |
| — Severely                        | 6.87   | 5.13–9.21| <0.001|
| — Septic shock                    | 10.47  | 7.30–15.03| <0.001|
| Severity score                    |        |          |       |
| — SAPS II > 45                    | 1.17   | 0.90–1.51| 0.218 |
| Admission day before              |        |          |       |
| — VAP onset > 7 days              | 1.35   | 1.12–1.64| 0.001 |

Table 5. Prognostic indicators of mortality of VAP patients by using multivariate Cox’s proportional hazards regression analysis

| Predictor                          | OR     | 95% CI   | P     |
|-----------------------------------|--------|----------|-------|
| Co-morbidity                      |        |          |       |
| — Renal diseases                  | 1.08   | 0.77–1.52| 0.653 |
| — Immunocompromised states        | 1.28   | 0.80–2.04| 0.292 |
| — Malignancy                      | 1.60   | 1.02–2.42| 0.040 |
| — Hematologic diseases            | 0.90   | 0.50–1.64| 0.678 |
| — Hepatic diseases                | 0.88   | 0.48–1.61| 0.689 |
| CXR: extents of infiltration      |        |          |       |
| — Single lobe                     | 0.84   | 0.51–1.38| 0.496 |
| — Multi-lobes                     | 0.80   | 0.67–1.07|       |
| Sepsis status                     |        |          |       |
| — Severe sepsis                   | 2.51   | 1.60–4.00| <0.001|
| Severity score                    |        |          |       |
| — SAPS II > 45                    | 1.62   | 1.03–2.56| 0.041 |
| — SOFA > 5                        | 3.40   | 2.00–5.81| <0.001|
| A. baumannii                      |        |          |       |
| — Drug sensitive                  | 1.23   | 0.51–3.00| 0.644 |
| — XDR-A. baumannii                | 1.72   | 0.77–3.80| 0.184 |
| — PDR-A. baumannii                | 1.82   | 0.56–6.00| 0.324 |
| Group of initial antibiotic treatment |    |          |       |
| — Early & appropriate             | 0.82   | 0.20–3.45| 0.786 |
| — Late & inappropriate            | 1.40   | 0.97–1.96| 0.072 |
| — Early & inappropriate           | 2.23   | 1.12–4.45| 0.022 |

see footnotes of Table 4.

DISCUSSION

Epidemiology: VAP is the commonest cause of nosocomial infection in medical ICU. Although guidelines for VAP prevention, including hand washing, elevation of the head of the bed, oral care with chlorhexidine, optimized endotracheal tube cuff pressure,
Epidemiology and Prognostic Factors for VAP in ICU

We found cut-off points of SAPS II >45 and SOFA score >5 had the best sensitivity and specificity for mortality (SAPS II >45 [sensitivity 80%, specificity 79.4%], SOFA >5 [sensitivity 87.7%, specificity 75.4%]) and were used in subsequent univariate and multivariate regression analyses. Our study demonstrated a high SAPS II score was associated with increased mortality (HR 1.05; 95% CI, 1.04–1.06; P < 0.001), particularly when greater than 45 (HR 6.8; 95% CI, 5.07–9.11; P < 0.001). Our findings corroborate a report by Tejerina et al. demonstrating the same SAPS II cut-off point as a predictor of VAP mortality (odds ratio 2.2; 95% CI, 1.4–3.5) (18).

Prognostic indicators of mortality: Prognostic indicators of VAP mortality in our patients included: illness severity, e.g., septic shock; late-onset VAP; multi-lobar respiratory infiltrates; high SOFA score; high SAPS II score; drug-resistant pathogens; A. baumannii infection; and inappropriate antibiotic treatment. These are in-keeping with previous studies (6,9,10,12,13). Underlying diseases, including malignancy, renal disease, immunocompromised status, and hepatic disease, have also been reported as prognostic indicators of hospital mortality (4,10,11).

The overall 30-day ICU, and hospital MR of 44.4%, 29.0%, and 51%, respectively were similar to previously reported studies. Varying VAP MR as high as 70% in specific settings, or when caused by drug-resistant pathogens, have been reported (2–4,6). The crude 30-day VAP mortality in Asian countries was reported as 44.8% (11.1%–66.7%). Our mortality rate was slightly higher than the 30% rate reported by Kollef et al. as our patients had more severe disease, demonstrated by high SAPS II (46.3 ± 14.2) and SOFA scores (6.6 ± 2.7). In addition, nearly half of our patients had septic shock, one of the strongest predictors of death.

In a large multicenter cohort study in France, the 30- and 60-day ICU mortalities of VAP patients were 23.3% and 25.6%, respectively. In this study, a high SAPS II score was a risk factor for death in ICU (HR 1.023; 95% CI, 1.011–1.034; P = 0.001) (6). We also found high SAPS II scores were associated with increased mortality, particularly SAPS II scores >45 (HR 6.87; 95% CI, 5.13–9.21; P < 0.001).

We found SOFA scores on the day of VAP diagnosis were significantly higher among non-survivors than they were in survivors (7 ± 3 vs. 4 ± 2; P = 0.002). We also demonstrated a SOFA score >5 on the day of VAP onset was a prognostic indicator of death. This was similar to a previous study demonstrating the SOFA score as a good predictor of mortality with discriminatory value (ROC AUC: 0.71; P = 0.005) (21). In addition, a systematic review of SOFA-based models as predictors of ICU mortality and a meta-analysis by Siempos et al. found the SOFA score improved mortality prediction (14,22).

The choice of initial antimicrobial therapy is an important predictor of clinical outcomes in VAP patients. The appropriateness and timing of the initial antibiotic therapy is important in reducing VAP mortality. A previous study demonstrated inadequate antibiotic treatment was associated with increased hospital mortality and subsequent change of antibiotic used following sensitivity results did not improve outcomes (13,23).

Our findings support previous studies that have shown the use of inappropriate empirical antibiotics, particularly when administered late was a predictor of mortality (10,12,19). Although empirical antibiotics were initiated early (within 24 h) in the majority of our patients (90.8%), appropriate antibiotics were used in only 59.3% of cases, whereas the rate of inappropriate antibiotic therapy was unacceptably high at 31.5%. This result likely explains the high VAP mortality rate in this study.

In addition to the choice of antibiotic used, the timing of treatment initiation is also important. The time antibiotic initiation was defined as the time between patients...
receiving antimicrobial agents and the diagnosis of VAP. Iregui et al. demonstrated VAP patients have poor outcomes when appropriate antimicrobial therapy is delayed (24). In our study, the primary reason for delayed treatment was delayed recognition of VAP. We found late and inappropriate antibiotic treatment was a predictor of poor outcomes in VAP. Although the timing of appropriate prescribed antibiotics had no significant effect on mortality in our study, there was a trend toward late prescription and poor prognosis.

Most of our patients were found to have severe sepsis and septic shock at the time of VAP diagnosis. The 2012 Surviving Sepsis Campaign guidelines suggest that one of the key factors in improving patient outcomes in severe sepsis and septic shock is the administration of an effective intravenous antimicrobial regimen within the first hour of diagnosis (7). As our study was retrospective, data regarding the time antibiotic administration following diagnosis of severe sepsis and septic shock were incomplete. The only modifiable risk factor identified in this study was delayed and inappropriate empirical antibiotic treatment. Therefore, administration of early and appropriate initial antibiotic treatment could improve VAP management.

Our study had limitations. Firstly, this study was conducted at a single university hospital. Therefore, our results may not be in-keeping with national epidemiological data. Secondly, our study did not report attributable VAP mortality, only crude, ICU, and hospital mortality. Thirdly, our retrospective study had incomplete data for some factors potentially related to mortality, including complications of mechanical ventilation, development of acute respiratory distress syndrome, and compliance to Sepsis Surviving Campaign guidelines for the management of severe sepsis and septic shock. In addition, compliance to VAP prevention guidelines was not monitored. Further prospective studies are required to fully evaluate prognostic indicators of VAP.

In conclusion, we found VAP is associated with high mortality. The major causative pathogen was drug-resistant A. baumannii. Prognostic indicators of mortality were malignancy, presence of septic shock, severity of illness (SAPS II score >45 and SOFA score >5) at VAP onset, and late inappropriate antibiotic treatment. Therefore, we believe the early detection of VAP among mechanically ventilated patients by surveillance could lead to earlier initiation of treatment, prevention of disease progression, and improve patient outcomes. We also recommend all hospitals develop infection control policies. In addition to developing protocols VAP prevention, infection control teams should perform periodic surveillance of local epidemiological data concerning causative organisms responsible for VAP cases in each hospital. Guidelines for the prescription of appropriate empirical antibiotics could then be established to cover bacterial strains identified using local epidemiological data.

Acknowledgments This study was supported by a grant from the Graduate School, Chiang Mai University.

Conflict of interest None to declare.

REFERENCES

1. American Thoracic Society and Infectious Diseases Society of America. Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. Am J Respir Crit Care Med. 2005;171:388-416.
2. Rello J, Ollendorf DA, Oster G, et al. Epidemiology and outcomes of ventilator-associated pneumonia in a large US database. Chest. 2002;122:2115-21.
3. Craven DE. Epidemiology of ventilator-associated pneumonia. Chest. 2000;117(4 Suppl 2):1865-1875.
4. Vincent JL, Rello J, Marshall J, et al. International study of the prevalence and outcomes of infection in intensive care units. JAMA. 2009;302:2329-39.
5. Yang YS, Lee YT, Huang TW, et al. Acinetobacter baumannii nosocomial pneumonia: is the outcome more favorable in nonventilated than ventilated patients? BMC Infect Dis. 2013;13:142.
6. Beketa M, Timis JT, Vansteelandt S, et al. Attributable mortality of ventilator-associated pneumonia: a reappraisal using causal analysis. Am J Respir Crit Care Med. 2011;184:1133-9.
7. Dellinger RP, Levy MM, Rhodes A, et al. Surviving sepsis campaign: international guidelines for management of severe sepsis and septic shock: 2012. Crit Care Med. 2013;41:580-637.
8. Magiorakos AP, Srinivasan A, Carey RB, et al. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance. Clin Microbiol Infect. 2012;18:268-81.
9. Chung DR, Song JH, Kim SH, et al. High prevalence of multidrug-resistant nonfermenters in hospital-acquired pneumonia in Asia. Am J Respir Crit Care Med. 2011;184:1409-17.
10. Chastre J, Fagon JY. Ventilator-associated pneumonia. Am J Respir Crit Care Med. 2002;165:567-90.
11. Arabi Y, Al-Shirawi N, Memish Z, et al. Ventilator-associated pneumonia in adults in developing countries: a systematic review. Int J Infect Dis. 2008;12:505-12.
12. Chang HC, Chen YC, Lin MC, et al. Mortality risk factors in patients with Acinetobacter baumannii ventilator: associated pneumonia. J Formos Med Assoc. 2011;110:564-71.
13. Teixeira PJ, Seligman R, Hertz FT, et al. Inadequate treatment of ventilator-associated pneumonia: risk factors and impact on outcomes. J Hosp Infect. 2007;65:361-7.
14. Siempos II, Vardakas KZ, Kyriakopoulos CE, et al. Predictors of mortality in adult patients with ventilator-associated pneumonia: a meta-analysis. Shock. 2010;33:590-601.
15. Chaari A, Menif B, Bahloul M, et al. Acinetobacter baumannii ventilator-associated pneumonia: epidemiology, clinical characteristics, and prognosis factors. Int J Infect Dis. 2013;17:e1225-8.
16. Marechal H, Layios N, Damas P. The severity of ICU-acquired Pneumonia. Curr Infect Dis Rep. 2013;15:380-4.
17. Fagon JY, Chastre J, Vuagnat A, et al. Nosocomial pneumonia and mortality among patients in intensive care units. JAMA. 1996;275:866-9.
18. Tejerina E, Frutos-Vivar F, Restrepo MI, et al. Incidence, risk factors, and outcome of ventilator-associated pneumonia. J Crit Care. 2006;21:56-65.
19. Leroy O, Meybeck A, d’Escrivain T, et al. Impact of adequacy of initial antimicrobial therapy on the prognosis of patients with ventilator-associated pneumonia. Intensive Care Med. 2003;29:2170-2.
20. Froon AH, Bonten MJ, Guillard CA, et al. Prediction of clinical severity and outcome of ventilator-associated pneumonia. Comparison of simplified acute physiology score with systemic inflammatory mediators. Am J Respir Crit Care Med. 1998;158:1026-31.
21. Gursel G, Demirtas S. Value of APACHE II, SOFA and CPIS scores in predicting prognosis in patients with ventilator-associated pneumonia. Respiration. 2006;73:503-8.
22. Minne L, Abu-Hanna A, de Jonge E. Evaluation of SOFA-based models for predicting mortality in the ICU: a systematic review. Crit Care. 2008;12:R161.
23. Luna CM, Vujacicich P, Niederman MS, et al. Impact of BAL data on the therapy and outcome of ventilator-associated pneumonia. Chest. 1997;111:676-85.
24. Iregui M, Ward S, Sherman G, et al. Clinical importance of delays in the initiation of appropriate antibiotic treatment for ventilator-associated pneumonia. Chest. 2002;122:262-8.