

Prediction of Requirement for Mechanical Ventilation in Community-Acquired Pneumonia with Acute Respiratory Failure: A Multicenter Prospective Study

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Key Words

Community-acquired pneumonia · Respiratory infection · A-DROP scoring system · Pneumonia Severity Index · Respiratory failure · Mechanical ventilation

Abstract

Background: Several severity scoring systems for predicting mortality are established in community-acquired pneumonia (CAP). **Objectives:** The predictability of the aggravation such as requirement for mechanical ventilation in addition to mortality was examined in CAP patients with acute respiratory failure by using the age, dehydration, respiratory failure, orientation disturbance and blood pressure (A-DROP) scoring system which was proposed by the Japanese Respiratory Society. **Methods:** This study was a prospective, multicenter, observational cohort study. The severity of pneumonia was examined using A-DROP and Pneumonia Severity Index (PSI) which originated from the Infectious Disease Society of America. Requirement for mechanical ventilation and mortality were evaluated for 28 days. **Results:** 482 CAP

patients with acute respiratory failure were enrolled in the study. The 28-day mortality and mechanical ventilation rates were 12.3 and 14.4%, respectively. There were no significant differences in the areas under the receiver-operator characteristic curves for prediction of mortality between A-DROP and PSI (χ^2 test; $p = 0.3613$). In the subgroup analyses by severity, the A-DROP scoring system showed a severity-dependent increase of mortality (moderate 5.6%, severe 16.1%, extremely severe 27.1%, Cochran-Armitage trend test; $p < 0.0001$). Similar results were obtained for mechanical ventilation rate (moderate 9.8%, severe 16.7%, extremely severe 25.4%, Cochran-Armitage trend test; $p = 0.0006$). The compliance with scoring the A-DROP was higher than that with scoring the PSI (96.9 vs. 71.6%). **Conclusions:** The results of this study suggest that the A-DROP scoring system could be a simple CAP risk scoring system which could predict not only mortality, but also the requirement for mechanical ventilation.

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Prof. Akitoshi Ishizaka deceased on September 20, 2009.

Introduction

Community-acquired pneumonia (CAP) is a common and potentially life-threatening disease. The initial assessment of severity is important for the management of CAP [1]. Several predictive rules have been developed for the assessment of CAP severity by different scientific societies. The Pneumonia Severity Index (PSI), which helps in the classification of patients according to mortality risk and could be used as a tool for detecting low-risk patients, is recommended by the American Thoracic Society (ATS) and the Infectious Disease Society of America (IDSA) [1, 2]. The PSI, however, has limitations. It is heavily weighted by age and comorbid illness, and the large number of variables makes it complex [3]. The confusion, urea, respiratory rate, blood pressure and age over 65 years (CURB-65) is a simple and mortality-correlate scoring system which is proposed by the British Thoracic Society [4]. In Japan, the age, dehydration, respiratory failure, orientation disturbance (confusion) and blood pressure (A-DROP) scoring system, which was a modified version of the CURB-65, was proposed by the Japanese Respiratory Society (JRS), and it was reported that the 30-day mortality in CAP assessed using the A-DROP scoring system was equivalent to that assessed using the CURB-65 [5, 6].

In CAP, when inflammation becomes severe and prolonged, lung tissue injury progresses, and hypoxemia secondary to impaired gas exchange, namely, acute respiratory failure, may develop. In some cases, this leads to acute lung injury, including the subset of acute respiratory distress syndrome (ARDS). These potentially life-threatening conditions require intensive management including mechanical ventilation. While the mortality rate of hospitalized CAP patients ranges from 10 to 25%, the mortality rate of severe CAP ranges from 22 to 54%; in particular, it is higher among CAP patients who require mechanical ventilation, which amounts to around 50% [7–12]. The requirement for mechanical ventilation is one of the major criteria for the identification of severe CAP in ATS/IDSA guidelines because of its strong association with mortality [1, 13]. Therefore, although these scoring systems focus on the prediction of mortality, it is also important to predict aggravation such as the requirement for mechanical ventilation and treat it appropriately at an early stage in clinical practice. In this study, the predictability of the aggravation in CAP such as the mechanical ventilation rate was examined by using the A-DROP scoring system.

Material and Methods

Study Design

A prospective observational cohort study was conducted between September 2008 and December 2009 at 135 sites, which included departments of internal medicine, respiratory medicine, or emergency medicine in 128 general hospitals and 7 university hospitals in Japan (Appendix). The study was performed according to the Japanese ethical guidelines for epidemiological studies and the study protocol was approved by the institutional review boards at the participating sites. Written informed consent was obtained from every patient before inclusion in the study.

Methods

Patients aged 20 years or older who developed acute respiratory failure without mechanical ventilation due to CAP requiring hospitalization were eligible. Acute respiratory failure was defined as arterial partial pressure of oxygen (PaO_2) ≤ 60 mm Hg or percutaneous oxygen saturation (SpO_2) $\leq 90\%$ without oxygen therapy. CAP was defined as pneumonia (1) which developed acutely without a history of hospitalization or admission to long-term care facilities within 2 weeks of onset; (2) which was accompanied by new and acute infiltrates seen on chest X-ray or CT within 48 h before enrollment; (3) which was accompanied by blood test results indicating leukocytosis (white blood cell counts $>10,000/\text{mm}^3$), increased band cells ($>15\%$), leukopenia (white blood cell counts $<4,500/\text{mm}^3$) or elevated C-reactive protein levels (exceeding the upper limit of normal values), and (4) with fever ($>37^\circ\text{C}$), respiratory symptoms including cough, purulent sputum, chest pain and dyspnea, or at least one abnormal finding on phonacoscopy (e.g. crackles, dullness to percussion and decreased breath sounds). Patients with noninfectious pneumonia, including interstitial pneumonia, eosinophilic pneumonia and hypersensitivity pneumonitis, pulmonary tuberculosis, organizing pneumonia and radiation pneumonitis, or patients with lung cancer were excluded from the study. Patients with hospital-acquired pneumonia occurring 48 h or more after hospitalization were also excluded. Antimicrobial agents were selected according to the JRS guidelines [5].

Each patient was followed for 28 days. Baseline characteristics such as the age, gender, pathogenic microorganism, and complications were recorded. To identify pathogenic microorganisms, sputum samples were obtained for bacterial testing prior to initiating first-line therapy. Causative organisms were identified by taking into account the number of viable cells and known pathogenicity. Moreover, the pathogens of atypical pneumonia, such as *Mycoplasma pneumoniae*, *Chlamydia pneumoniae* and *Legionella pneumophila*, were identified by an acute-phase serologic test (complement fixation and particle agglutination methods) and Immuno-Card test (serum enzyme immunoassay methods; Nihon TFB Co., Ltd., Tokyo, Japan). The severity classification of pneumonia was evaluated according to A-DROP [5] and PSI [1, 2]. The A-DROP scoring system was summarized in table 1. The total score for A-DROP of the 6-point scoring system was calculated by adding a point for (1) age (≥ 70 years for male, ≥ 75 years for female); (2) dehydration (blood urea nitrogen ≥ 21 mg/dl); (3) respiratory failure ($\text{SpO}_2 \leq 90\%$ or $\text{PaO}_2 \leq 60$ mm Hg); (4) orientation disturbance (confusion judged by each physician in consideration of complications, such as basic neurological complication), or (5) low blood pressure (systolic blood pressure ≤ 90 mm Hg) and patients were stratified into four severity classes (mild = 0; moderate = 1 or 2; se-

Table 1. A-DROP scoring system

| Items | Criteria |
|-------------------------------------|---|
| Age | male ≥ 70 years, female ≥ 75 years |
| Dehydration | BUN ≥ 21 mg/dl |
| Respiratory failure | PaO ₂ ≤ 60 Torr or SpO ₂ $\leq 90\%$ |
| Orientation disturbance (confusion) | |
| Blood pressure | systolic blood pressure ≤ 90 mm Hg |

| Severity | | Treatment options |
|-------------|------------------|-------------------------------|
| total score | classification | |
| 0 | mild | outpatient |
| 1 or 2 | moderate | outpatient or hospitalization |
| 3 | severe | hospitalization |
| 4 or 5 | extremely severe | ICU |

The total score for A-DROP of a 6-point scoring system was calculated by adding a point for each item. BUN = Blood urea nitrogen.

vere = 3; extremely severe = 4 or 5). PSI was calculated using age, gender, nursing home residence, 5 comorbid, vital signs on admission, mental status, 7 laboratory values, and the findings on chest X-ray films at presentation. Patients were stratified into class I to class V according to PSI. The use of antibiotic agents and administration of oxygen were surveyed over the observation period. As clinical outcomes, requirement for mechanical ventilation (invasive and noninvasive mechanical ventilation), development of ARDS, admission to intensive care unit (ICU) and hospital discharge and mortality were surveyed. Requirement for mechanical ventilation, admission to ICU, hospital discharge, and discontinuation of oxygen and antibiotics were decided on by each physician. ARDS was judged according to the definitions of the American-European Consensus Conference on ARDS [14]. Briefly, it included of following criteria: (1) arterial partial pressure of oxygen/fraction of inspired oxygen (PaO₂/FiO₂) ratio ≤ 200 mm Hg, (2) bilateral infiltrates on chest X-ray, and (3) pulmonary edema of noncardiogenic origin (pulmonary capillary wedge pressure ≤ 18 mm Hg or, in the absence of pulmonary capillary wedge pressure measurement, nonclinical evidence of elevated left atrial pressure).

Statistical Analysis

The receiver-operator characteristic curves (ROC) and the areas under the ROC curves for mortality, which show the trade-off between sensitivity and specificity, were calculated for A-DROP and PSI [15]. The difference between the areas under the ROC curves was tested using the χ^2 test [16]. Mechanical ventilation rate, incidence of ARDS, ICU admission rate, and mortality rate, which were categorized by the severity classification of the A-DROP scoring system or PSI, were tested using the Cochran-Armitage trend test [17]. The mechanical ventilation rate was calculated including patients who were judged by the physician to require mechanical ventilation but did not actually receive it for reasons such as refusal by patients or their families.

Table 2. Baseline characteristics

| Variables | Patients (n = 482) |
|--|--------------------|
| Male gender | 353 (73.2) |
| Age, years | 76.3 \pm 12.0 |
| Age ≥ 65 years | 411 (85.3) |
| Male ≥ 70 years, female ≥ 75 years | 349 (72.4) |
| Respiratory rate, breaths/min | 24.3 \pm 6.4 |
| Pulse rate, breaths/min | 93.0 \pm 18.9 |
| Body temperature, °C | 37.5 \pm 1.0 |
| Systolic blood pressure, mm Hg | 125.8 \pm 23.7 |
| PaO ₂ , mm Hg | 64.0 \pm 20.4 |
| SpO ₂ , % | 90.7 \pm 6.3 |
| Chronic respiratory complications ¹ | 227 (47.1) |
| COPD | 126 (26.1) |
| Asthma | 61 (12.7) |
| Old tuberculosis | 27 (5.6) |
| Pulmonary fibrosis | 13 (2.7) |
| Bronchiectasis | 10 (2.1) |
| Compliance with scoring | |
| A-DROP scoring system | 467 (96.9) |
| PSI | 345 (71.6) |

Data are presented as n (%) or mean \pm SD. COPD = Chronic obstructive pulmonary disease.

¹ Including mixed complication cases.

Results

Patient Characteristics

Four hundred eighty-two patients were enrolled in the study. Table 2 summarizes the baseline characteristics of all patients. The study population comprised 482 patients with a mean (\pm SD) age of 76.3 (\pm 12.0) years (range, 21–102 years); 73.2% were male. Overall, 47.1% patients were found to have one or more coexisting chronic respiratory disease, including chronic obstructive pulmonary disease, asthma, old tuberculosis, pulmonary fibrosis, and bronchiectasis.

The compliance with scoring the A-DROP and PSI were 96.9% (467 of 482 patients) and 71.6% (345 of 482 patients), respectively. The mean (\pm SD) numbers of A-DROP and PSI were 2.6 (\pm 0.7) and 107.1 (\pm 31.4), respectively. The severity classification by A-DROP at enrollment was moderate in 234 (50.1%), severe in 174 (37.3%) and extremely severe in 59 (12.6%) patients. There were no patients categorized as mild because the study was conducted in patients with acute respiratory failure. The severity classification by PSI was class I in 4 (1.2%), II in 18 (5.2%), III in 72 (20.9%), IV in 184 (53.3%) and V in 67 (19.4%) patients.

Table 3. Pathogenic microorganisms (including mixed infection cases)

| | Patients (n = 482) |
|------------------------------------|--------------------|
| <i>Streptococcus pneumoniae</i> | 27.0 (130) |
| <i>Staphylococcus aureus</i> | 9.3 (45) |
| <i>Haemophilus influenzae</i> | 8.5 (41) |
| <i>Klebsiella pneumoniae</i> | 4.6 (22) |
| <i>Pseudomonas aeruginosa</i> | 3.3 (16) |
| <i>Mycoplasma pneumoniae</i> | 3.1 (15) |
| <i>Neisseria</i> ssp. | 2.3 (11) |
| <i>Moraxella catarrhalis</i> | 1.7 (8) |
| <i>Chlamydia pneumoniae</i> | 1.2 (6) |
| <i>Legionella pneumophila</i> | 1.0 (5) |
| Virus | 1.0 (5) |
| <i>Serratia marcescens</i> | 0.6 (3) |
| <i>Acinetobacter calcoaceticus</i> | 0.4 (2) |
| Unknown | 38.2 (184) |

Data are presented as % (n).

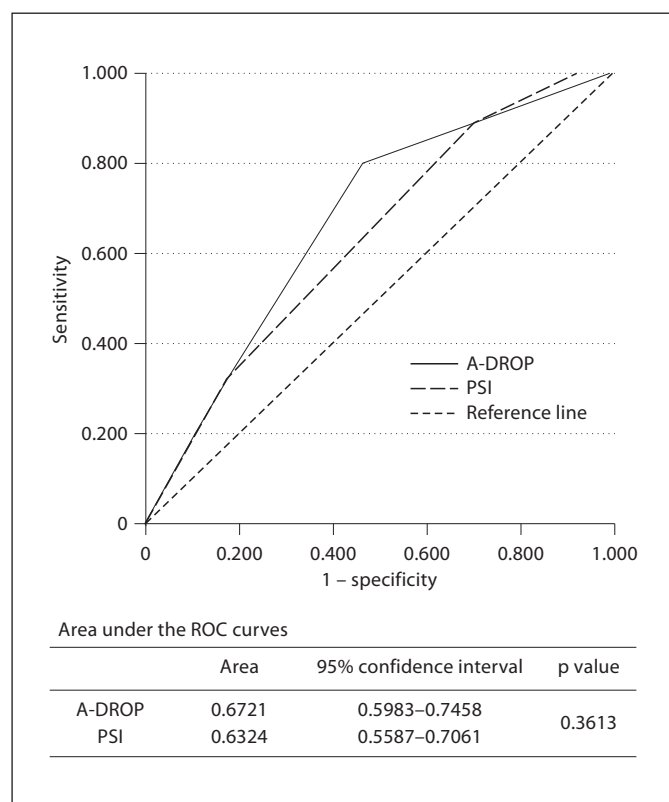


Fig. 1. ROC curves of the A-DROP and PSI for mortality. The difference in the areas under the ROC curves between A-DROP and PSI was tested using the χ^2 test.

Table 4. Initial antibiotic agents (including mixed infection cases)

| | Bacterial pneumonia (n = 287) | Atypical pneumonia ¹ (n = 24) | Unknown (n = 184) |
|------------------|-------------------------------|--|-------------------|
| Penicillins | 54.7% | 41.7% | 44.6% |
| Cephalosporins | 43.2% | 37.5% | 41.3% |
| Fluoroquinolones | 33.1% | 54.2% | 26.6% |
| Carbapenems | 32.1% | 16.7% | 25.5% |
| Macrolides | 12.5% | 16.7% | 12.0% |
| Lincomycins | 9.1% | 8.3% | 9.8% |
| Tetracyclines | 6.3% | 29.2% | 7.6% |
| Glycopeptides | 5.2% | 4.2% | 4.3% |
| Aminoglycosides | 3.5% | 4.2% | 1.6% |
| Oxazolidinones | 1.7% | 0% | 0% |

¹ Atypical pneumonia includes *M. pneumoniae*, *C. pneumoniae* and *L. pneumophila*.

Pathogen Distribution and Antibiotic Treatment

The pathogens are summarized in table 3. They were found in 298 patients (61.8%). *Streptococcus pneumoniae*, *Staphylococcus aureus* and *Haemophilus influenzae* were the most frequently isolated pathogens. Table 4 shows the initial antibiotic treatment. The JRS guidelines have proposed a differential diagnosis for bacterial pneumonia and atypical pneumonia, including *M. pneumoniae* and *C. pneumoniae* for the selection of an appropriate antibiotic agent [5]. The initial antibiotic treatment in this study was summarized for each type of pneumonia. The most frequent initial antibiotic treatments were penicillins, cephalosporins, fluoroquinolones and carbapenems for the treatment of bacterial pneumonia in 54.7, 43.2, 33.1 and 32.1% of the patients, respectively. Fluoroquinolones were used for the majority of patients (54.2%) with atypical pneumonia, but tetracyclines and macrolides were used in 29.2 and 16.7%, respectively, which are less frequent than penicillins (41.7%) and cephalosporins (37.5%).

Comparison between A-DROP and PSI in Prediction of Mortality

The 28-day mortality rate was 12.3% (58 of 472 patients). The ROC curves for mortality are shown in figure 1. The areas under the ROC curves were 0.6721 (95% confidence interval: 0.5983–0.7458) and 0.6324 (95% confidence interval: 0.5587–0.7061) for A-DROP and PSI, respectively. There was no significant difference in the areas

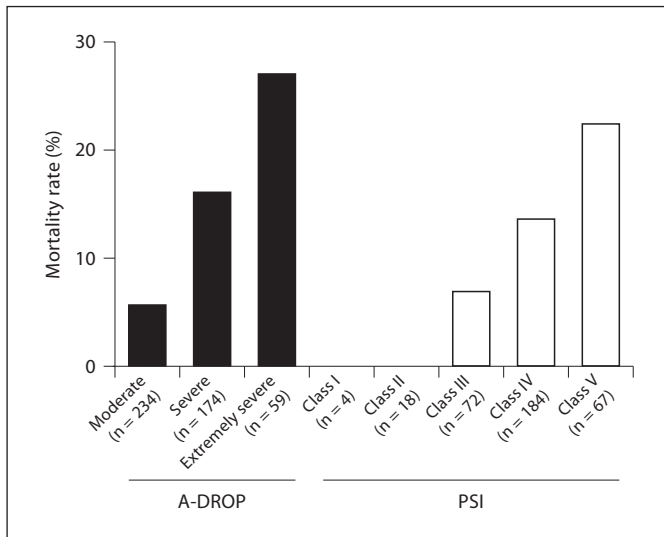


Fig. 2. The results of the subgroup analysis of the mortality rate according to the severity classification of A-DROP and PSI. Linearity of the mortality rate according to the severity classification of A-DROP and PSI was tested using the two-sided Cochran-Armitage trend test, $p < 0.0001$ and $p = 0.0006$, respectively.

under the ROC curves between A-DROP and PSI (χ^2 test; $p = 0.3613$). Figure 2 shows the results of the subgroup analysis for the mortality rate according to the severity classification of A-DROP and PSI. In the subgroup analysis by the severity classification of A-DROP, the mortality rate was 5.6% (13 of 234 patients) in patients classified as moderate, 16.1% (28 of 174 patients) in severe and 27.1% (16 of 59 patients) in extremely severe, indicating an increase in mortality rate in accordance with severity (Cochran-Armitage trend test; $p < 0.0001$). In the subgroup analysis by the severity classification of PSI, the mortality rate was 0% (0 of 4 patients) in patients classified as class I, 0% (0 of 18 patients) in class II, 6.9% (5 of 72 patients) in class III, 13.6% (25 of 184 patients) in class IV and 22.4% (15 of 67 patients) in class V, indicating an increase in the mortality rate in accordance with severity (Cochran-Armitage trend test; $p = 0.0006$).

Requirement for Mechanical Ventilation and Other Clinical Outcomes

The 28-day mechanical ventilation rate was 14.4% (68 of 472 patients). Among 68 patients requiring mechanical ventilation, 13 patients (19.1%) received only noninvasive mechanical ventilation, 32 patients (47.1%) only invasive mechanical ventilation, 8 patients (11.8%) both of nonin-

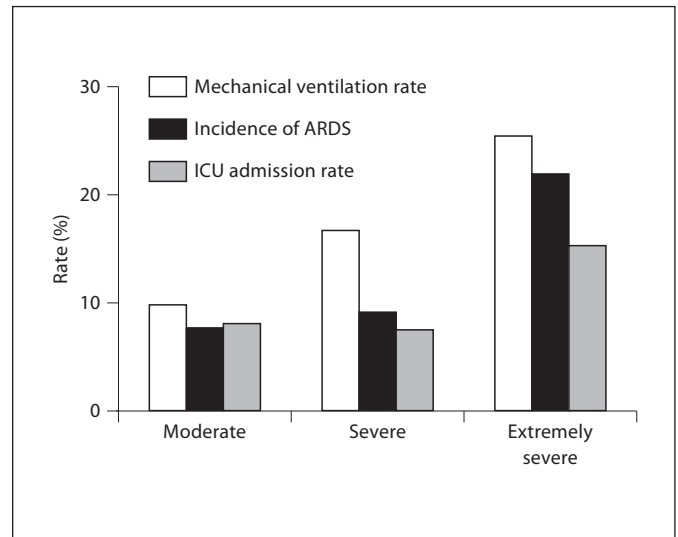


Fig. 3. The results of the subgroup analysis on mechanical ventilation rate, incidence of ARDS, and ICU admission rate according to the severity classification of A-DROP. Linearity of each rate according to the severity classification of A-DROP was tested using the two-sided Cochran-Armitage trend test, $p = 0.0006$, $p = 0.0027$, and $p = 0.1046$, respectively.

vasive and invasive mechanical ventilation, and 15 patients (22.1%) refused mechanical ventilation. The incidence of ARDS was 10.0% (47 of 472 patients), and ICU admission rate was 8.7% (41 of 472 patients). The 28-day hospital discharge rate was 62.9% (297 of 472 patients), the rate of discontinuation of oxygen was 68.9% (325 of 472 patients), and the rate of discontinuation of antibiotic treatment 72.2% (341 of 472 patients). Figure 3 shows the results of the subgroup analysis of the mechanical ventilation rate, the incidence of ARDS, and ICU admission rate according to severity classification of A-DROP. In the subgroup analysis by the severity classification of A-DROP, the mechanical ventilation rate was 9.8% (23 of 234 patients) in patients classified as moderate, 16.7% (29 of 174 patients) in those classified as severe and 25.4% (15 of 59 patients) in the extremely severe, indicating an increase in the requirement for mechanical ventilation in accordance with severity (Cochran-Armitage trend test; $p = 0.0006$). While the result of the incidence of ARDS was similar to that of the mechanical ventilation rate (Cochran-Armitage trend test; $p = 0.0027$), no clear relationship was found between ICU admission rate and the severity of A-DROP (Cochran-Armitage trend test; $p = 0.1046$).

Discussion

This study was a prospective observational cohort study which examined the utility of A-DROP, the severity classification method for CAP proposed by JRS, in predicting the requirement for mechanical ventilation. The results confirmed higher mechanical ventilation rates among the more severe cases according to A-DROP. There was no difference in the areas under the ROC curves for mortality between A-DROP and PSI. The mortality rate increased in accordance with severity as assessed by A-DROP.

Mechanical ventilation is not only stressful for patients and deteriorates their quality of life, but also causes various complications including ventilator-associated pneumonia and lung injury, further elevating the risk of mortality [18–20]. In addition to creating substantial suffering for patients, mechanical ventilation also incurs considerable medical expense [21]. Torres et al. [9] found in their study that the requirement for mechanical ventilation, among other variables, was associated with mortality in severe CAP patients. Liapikou et al. [13] also reported that the requirement for mechanical ventilation, which was one of the major criteria for the identification of severe CAP in ATS/IDSA guidelines, had a high sensitivity and specificity in predicting hospital mortality. Therefore, it is important to simply predict the aggravation such as the requirement for mechanical ventilation and treat patients appropriately at an early stage in clinical practice.

In this study, the mean age was 76.3 years and the most frequent microorganism was *S. pneumoniae* followed by *S. aureus* and *H. influenzae*; they were comparable to a recent study conducted in Japan, although the chronic respiratory complication rates were higher in this study than that in a recent study (47.1 and 32.5%, respectively) [6]. The mechanical ventilation and mortality rates were higher in this study than those in the recent study (14.4 vs. 7.0% for mechanical ventilation and 12.3 vs. 9.4% for mortality, respectively) [6]. In addition, mortality according to A-DROP severity classification in our recent report amounted to 3.1% in mild, 9.9% in severe, and 19.6% in extremely severe, which was lower than that in the present study (9.8, 16.7 and 25.4%, respectively) [22]. Although CAP patients with acute respiratory failure were enrolled in the present study, CAP patients regardless of the presence of acute respiratory failure were enrolled in the recent studies. In addition, in the present study, the mechanical ventilation rate was calculated including patients who were judged by the physician to require mechanical ventilation but did not actually receive it because

of their refusal or that of their families. It is conceivable that differences in the study population (e.g. acute respiratory failure, frequent chronic respiratory complications) or the analysis methods of the mechanical ventilation rates could account for a higher mechanical ventilation rate and mortality rate in this study. The mechanical ventilation rate calculated from patients who actually underwent mechanical ventilation was 8.3%, showing an increase in a severity-dependent manner as with the mechanical ventilation rate calculated using the original method in this study (data not shown).

As options for antibiotic therapy are increasing, appropriate initial treatment should be started early not only in the interest of patients but also from the perspective of medical cost [23]. In the present study, the initial antibiotic treatment was consistent with the JRS guidelines, with penicillins including β -lactamase inhibitors used for approximately half of the patients with bacterial pneumonia, although fluoroquinolones were also frequently used. For atypical pneumonia such as *M. pneumoniae* and *C. pneumoniae*, fluoroquinolones were used more frequently than tetracyclines and macrolides. The use of macrolides is recommended especially in severe CAP because of its greater efficiency or cost-benefit compared with tetracyclines or fluoroquinolones [24]. JRS guidelines also recommend the use of macrolides combined with β -lactams especially in cases suspected as atypical pneumonia, but do not recommend the use of fluoroquinolones as first-line therapy [5]. The frequent use of fluoroquinolones in this study may be the result of the large number of patients with chronic respiratory disease.

Beneficial effects of noninvasive mechanical ventilation have been shown in CAP patients with acute respiratory failure [25–27]. In the present study, in 21 patients noninvasive mechanical ventilation was applied and in 13 of the 21 patients (61.9%) endotracheal intubation could be avoided. Although the patient number was limited in this study, the efficacy of noninvasive mechanical ventilation for CAP patients with acute respiratory failure was consistent with prior studies.

There were no significant differences in the areas under the ROC curves for mortality between the A-DROP and PSI, and both the severity of the A-DROP and PSI showed a clear correlation with the mortality in the present study. The A-DROP scoring system is a modified version of the CURB-65 and it is reported that performance of CURB-65 in mortality deteriorated with increasing age (≥ 65 years) [28]. AUC of ROC curves for mortality in A-DROP scoring system in this study, 0.8750 (95% confidence interval: 0.6300–1.0000) in those aged <65 years

and 0.6374 (95% confidence interval: 0.3204–0.9544) in those aged ≥ 65 years, showed a similar trend. There was a clear relationship between the severity of the A-DROP scoring system and either the mechanical ventilation rate or the incidence of ARDS. The PSI also showed similar results in the mechanical ventilation rate and the incidence of ARDS (data not shown). Lee and Lindstrom [3] reported that the compliance with scoring the PSI was 33%. Although the compliance with scoring the PSI in this study (71.6%) is higher than that reported by Lee and Lindstrom, it was lower than the compliance with scoring A-DROP (96.9%). Therefore, although careful attention should be paid to the interpretation of the A-DROP score in older patients, these results indicated that A-DROP would be the more simple and useful scoring system in clinical practice.

On the other hand, the severity of the A-DROP scoring system showed no significant correlation with the ICU admission rate. The PSI also showed no significant correlation with the ICU admission rate (data not shown). Currently, many institutions provide intensive care including mechanical ventilation management not only in an ICU but also in a general ward. This may have influenced the result that no clear relationship between the severity and the ICU admission rate was observed.

In this study, outpatients were excluded. Since it is reported that despite guideline-based severity assessment, the physician's judgment of outpatient or hospitalization may be based on the patient's concomitant comorbid illnesses [29], each physician's judgment of outpatient or hospitalization might have influenced the present results. Patients without acute respiratory failure were excluded in this study. In addition, patients with aspiration pneumonia and health care-associated pneumonia, which should be clearly distinguished from CAP based on JRS or ATS/IDSA guidelines, were not excluded. Therefore, in the future, studies that include or exclude these patients are required to confirm the present study results. In this study, the A-DROP scoring system was compared with PSI but not CURB-65. Therefore, further investigations which compare the clinical usefulness of the A-DROP scoring system and CURB-65 will be needed.

In conclusion, the present study demonstrated that the mechanical ventilation and mortality rates in CAP patients with acute respiratory failure increased depending on the severity classified according to the A-DROP scoring system. The results of this study suggest that the A-DROP scoring system could be a simple CAP risk scoring system which could predict not only mortality but also the requirement for mechanical ventilation.

Appendix

Institutions Participating in the Study

Aidu Chuo Hospital, Department of Emergency and Critical Care Center; Omuta Tenryou Hospital, Department of Respiratory Medicine; Nagata Hospital, Department of Respiratory Medicine; Shizuoka Medical Center, Department of Internal Medicine; Nagasaki Medical Center of Psychiatry, Department of Respiratory Medicine; Nagasaki Genbaku Hospital, Department of Respiratory Medicine; Sasebo City Hospital, Department of Respiratory Medicine; Saiseikai Kumamoto Hospital, Department of Respiratory Center; Japanese Red Cross Fukuoka Hospital, Department of Emergency Medicine; Kumamoto Saishunso National Hospital, Department of Respiratory Medicine; University of Miyazaki Hospital, Department of Internal Medicine; Ureshino Medical Center, Department of Respiratory Medicine; Kumamoto Minami Hospital, Department of Respiratory Medicine; Nagasaki Genbaku Isahaya Hospital, Department of Respiratory Medicine; Isahaya Health Insurance General Hospital, Department of Respiratory Medicine; Kinki Central Hospital, Department of Respiratory Medicine; Japanese Red Cross Osaka Hospital, Department of Respiratory Medicine; Kishiwada City Hospital, Department of Respiratory Medicine; Matsusaka City Hospital, Department of Respiratory Medicine; Iwata City Hospital, Department of Respiratory Medicine; Tosei General Hospital, Department of Respiratory and Allergy Medicine; Ibaraki Seinan Medical Center Hospital, Department of Respiratory Medicine; Dokkyo Medical University Hospital, Department of Respiratory and Allergy Medicine; Mito Medical Center, Department of Respiratory Medicine; Japanese Red Cross Nagano Hospital, Department of Respiratory Medicine; JR Sapporo Hospital, Department of Respiratory Medicine; Noshiro Yamamoto Medical Association Hospital, Department of Chest Surgery; Morioka Tsunagi Onsen Hospital, Department of Internal Medicine; Japanese Red Cross Morioka Hospital, Department of Respiratory Medicine; Okitama Public General Hospital, Department of Internal Medicine; Ohta Nishinouchi Hospital, Department of Respiratory Medicine; Yamagata Saiseikai Hospital, Department of Respiratory Medicine; Yamagata City Hospital Saiseikan, Department of Respiratory Medicine; Japanese Red Cross Nagoya Daiichi Hospital, Department of Respiratory Medicine; Fukuoka Higashi Medical Center, Department of Respiratory Medicine; Nagasaki Rousai Hospital, Department of Emergency and Intensive Care Medicine; Sakura Medical Center, Toho University, Department of Respiratory Medicine; Nippon Medical School Chiba Hokusoh Hospital, Department of Emergency and Critical Care Center; Nippon Medical School Chiba Hokusoh Hospital, Department of Respiratory Medicine; Nagasaki University Hospital, Department of Respiratory Medicine; Nagasaki Medical Center, Department of Respiratory Medicine; Tokyo Metropolitan Hiroo Hospital, Department of Respiratory Medicine; Nippon Koukan Hospital, Department of Internal Medicine; Kanagawa Cardiovascular and Respiratory Center, Department of Respiratory Medicine; Nihon University Itabashi Hospital, Department of Respiratory Medicine; Japanese Red Cross Nagaoka Hospital, Department of Respiratory Medicine; Eiju General Hospital, Department of Respiratory Medicine; Kido Hospital, Department of Internal Medicine; Saiseikai Niigata Daini Hospital, Department of Respiratory Medicine; Niigata City General Hospital, Department of Respiratory Medicine; Shibata Hospital, Department of

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