APACHE II Predicts Long-term Survival in COPD Patients Admitted to a General Medical Ward

Anupam Goel, MD, Richard G. Pinckney, MD, MPH, Benjamin Littenberg, MD

OBJECTIVE: The Acute Physiology and Chronic Health Evaluation II (APACHE II) was developed to predict intensive-care unit (ICU) resource utilization. This study tested APACHE II's ability to predict long-term survival of patients with chronic obstructive pulmonary disease (COPD) admitted to general medical floors.

DESIGN: We performed a retrospective cohort study of patients admitted for COPD exacerbation outside the ICU. APACHE II scores were calculated by chart review. Mortality was determined by the Social Security Death Index. We tested the association between APACHE II scores and long-term mortality with Cox regression and logistic regression.

PATIENTS: The analysis included 92 patients admitted for COPD exacerbation in two Burlington, Vermont hospitals between January 1995 and June 1996.

MEASUREMENTS AND MAIN RESULTS: In Cox regression, APACHE II score (hazard ratio [HR] 1.76 for each increase in a 3-level categorization, 95% confidence interval [CI] 1.16 to 2.65) and comorbidity (HR 2.58; 95% CI, 1.36 to 4.88) were associated with long-term mortality ($P < .05$) in the univariate analysis. After controlling for smoking history, comorbidity, and admission pCO_2 , APACHE II score was independently associated with long-term mortality (HR 2.19; 95% CI, 1.27 to 3.80). In univariate logistic regression, APACHE II score (odds ratio [OR] 2.31; 95% confidence interval [CI] 1.24 to 4.30) and admission pCO_2 (OR 4.18; 95% CI, 1.15 to 15.21) were associated with death at 3 years. After controlling for smoking history, comorbidity, and admission pCO_2 , APACHE II score was independently associated with death at 3 years (OR 2.62; 95% CI, 1.12 to 6.16).

CONCLUSION: APACHE II score may be useful in predicting long-term mortality for COPD patients admitted outside the ICU.

KEY WORDS: APACHE II, COPD, long-term survival.

J GEN INTERN MED 2003; 18:824-830.

Prognostic information is important for providers, patients, and families. Although mortality is predictable in some settings, there are few tools to predict long-term survival in hospital inpatients outside of intensive care.¹ Prognostic tools validated in other settings could be extended to general inpatient medicine. One such validated prognostic tool is the Acute Physiology and Chronic Health Evaluation II (APACHE II).

Knaus et al. developed the original APACHE using physiologic variables and chronic health status to assess

intensive-care unit (ICU) resource utilization.² Later, the original instrument was refined as the APACHE II by decreasing the number of physiologic variables and including age in the score.³ The APACHE II score contains three components: age, acute physiologic score (APS), and chronic health. The total APACHE II score ranges from 0 to 71. A higher score implies a less favorable prognosis. The original APACHE II article noted no patient with a score greater than 55. Age can contribute up to 6 points. The APS includes physiologic variables and the Glasgow Coma Score (GCS), a bedside neurologic score incorporating best eye, verbal, and motor responses.⁴ The 11 physiologic variables in the APS can contribute up to 4 points each. The patient's GCS can add a further 15 points. Immunocompromised patients or those with severe organ system insufficiency receive 5 points for chronic health.

In addition to ICU resource utilization, the APACHE II has been used to predict long-term survival. The APACHE II score is strongly associated with long-term survival in general cohorts of ICU patients.^{5,6} It is less predictive of long-term survival with selected cohorts of ICU patients such as in-hospital survivors of cardiopulmonary arrest and patients with *Pneumocystis carinii* infection.^{7,8}

The APACHE II has rarely been studied outside the ICU. Rubin et al. found a monotonic inverse relationship between APACHE II score and 30-day survival in patients receiving a transjugular intrahepatic portosystemic shunt.⁹ El-Shahawy et al. found that APACHE II score was correlated with mortality in 222 patients with acute tubular necrosis.¹⁰ Extending the APACHE II outside the ICU may be useful in predicting long-term survival.

Patients with chronic obstructive pulmonary disease (COPD) exacerbation represent a spectrum of disease with a wide range of acuity. We suspect the pathophysiology of COPD exacerbation in patients admitted to the general medical floor is similar to the disease process in patients admitted to the ICU. Many of the components of APACHE II (i.e., age, oxygenation, anemia, renal insufficiency, and immunosuppression) appear to be related to mortality. This makes COPD exacerbation a good candidate disease for extending the APACHE II outside the ICU.

The APACHE II has been used to predict inpatient and long-term survival in COPD patients admitted to the ICU.^{11,12} Afessa et al. studied 180 patients admitted to an ICU for COPD exacerbation requiring intubation.¹¹ APACHE II score was independently associated with hospital outcome. Breen et al. studied 74 patients admitted to the ICU for COPD exacerbation and found the partial presence of carbon dioxide (pCO_2) and APACHE II scores were independently associated with inpatient mortality.¹² They found no significant predictors of long-term survival.

Received from the Division of General Internal Medicine, Wayne State University (AG), Detroit, Mich; the Division of General Internal Medicine, University of Vermont (RGP, BL), Burlington, Vt.

Address correspondence and requests for reprints to Dr. Anupam Goel, 4201 St. Antoine, Pod 5C, Detroit, MI 48201 (e-mail: agoel@intmed.wayne.edu).

Other variables have been used to predict mortality for patients with COPD. In an official statement by the American Thoracic Society, predictors of mortality for COPD patients include advancing age, severity of airflow obstruction, severity of hypoxemia, and presence of hypercapnia.¹³ Connors et al. found lower body-mass index, reduced functional status prior to hospital admission, history of congestive heart failure, and low serum albumin to be associated with 6-month mortality in a cohort of patients admitted to the ICU for COPD exacerbation.¹⁴

To our knowledge, the APACHE II has not been used to predict long-term mortality for COPD patients on a general medical ward. We designed a study to evaluate its ability to predict long-term mortality for patients admitted for COPD exacerbation to a general medical floor.

METHODS

Subjects and Setting

Potential subjects were identified by a principal discharge International Classification of Disease, 9th revision code of 490 (bronchitis, not specified as acute or chronic), 491 (chronic bronchitis), 492 (emphysema), 496 (chronic airway obstruction, not elsewhere classified), 518.81–0.84 (acute respiratory failure, other pulmonary insufficiency not elsewhere classified, chronic respiratory failure, and acute and chronic respiratory failure), 786.09 (dyspnea and respiratory abnormalities excluding hyperventilation, orthopnea, apnea, Cheyne-Stokes respiration, shortness of breath, tachypnea, or wheezing), or 799.1 (respiratory arrest) in either of two Burlington, Vt hospitals.¹⁵ The Fanny Allen Hospital was a private, 100-bed, Catholic hospital. The Medical Center Hospital of Vermont was a nonprofit, university-affiliated, 562-bed hospital. Both hospitals have since been assimilated into the Fletcher Allen Health Care system.

Study patients had to be at least 35 years old and admitted between January 1995 and June 1996. There are currently no objective admission criteria for COPD exacerbation.^{13,16,17} A combination of dyspnea severity, short-term response to emergency therapeutic efforts, and comorbid conditions all contribute to the decision to admit. In this study, all subjects met at least two of the following admission criteria, as recorded in the physician's admission note: increased frequency of cough, increased sputum production, increased dyspnea, or respiratory failure. Study patients with an admission chest x-ray consistent with congestive heart failure, pneumonia, or bronchiectasis were excluded. Patients with an asthma history or without a tobacco history were also excluded. Finally, patients without a Social Security number and those transferred from outside hospitals or the ICU were excluded. If patients were admitted multiple times during the study period, the index admission was randomly selected. The Committee on Human Research at the University of Vermont approved the study. There were no conflicts of interest in the design or execution of this study.

Data Collection

Demographic, physiologic, laboratory, and comorbidity characteristics were collected for each patient from the admission note, prior admission records, and the problem list. All data were collected using standardized forms and methods. One author recorded all of the data from patient records (RGP). Two individuals entered the data into a computer independently and the files were compared for discrepancies. Differences were resolved, and extreme values were examined by rechecking the data collection forms.

We modified the APS to reflect differences in general medical floor admission practices. To calculate the APS, missing values were considered normal. Instead of using the worst vital signs in the first 24 hours of admission as documented by the APACHE II, we used admission vital signs. Oral or tympanic temperatures were used instead of rectal readings. We recorded admission arterial blood gas (ABG) results with the other information required for APACHE II score determination.

Comorbidity was measured by the Charlson comorbidity index,¹⁸ which weights each of 11 medical conditions based on severity. It includes cardiac, gastrointestinal, renal, diabetic, neurologic, rheumatologic, HIV, and oncologic components. Pulmonary conditions were not considered comorbidities.

Vital status was determined by the Social Security Death Index (SSDI). The SSDI includes Social Security number, full name, date of birth, and date of death. The SSDI has been used in other studies to determine survival.^{19,20} If a patient was not recorded in the initial SSDI review, the SSDI was reviewed at least once again at a later date. Time of observation for the survival analysis was the time from the date of index admission to either the date of death or the date of latest SSDI review.

Statistical Analysis

Our primary analysis was a Cox proportional hazards model of the association between APACHE II and long-term mortality. Of the established predictors of survival in COPD patients, Forced expiratory volume (FEV₁) was not available. We included gender, current smoking status, smoking history, comorbidity, length of stay, (pO₂) at admission, and partial pressure of oxygen (pCO₂) as covariates. Using the 7 available covariates, there are 128 potential combinations of predictors for the multivariate analysis of mortality. To direct the search for the best combination of predictors, we employed an algorithm to determine which variables would be included in the multivariate model. If a covariate was associated with mortality with at least $P < .2$, the covariate was entered into the multivariate model with APACHE II. We tested APACHE II and relevant covariates in a multivariate model with Schoenfeld residuals to check the validity of the proportional hazards assumption.²¹ For another interpretation of the data, we also tested the association between APACHE II and death at 3 years using logistic regression.

Table 1. Demographic, Comorbidity, and Survival Data for 92 Chronic Obstructive Pulmonary Disease Patients Admitted to a General Medical Ward

Characteristic	Result
Female, % (n)	52 (48)
Median age (range)	70 years (53–93)
Caucasian, % (n)	100 (92)
Current smokers, % (n)	39 (33)*
Median lifetime cigarette use (range)	60 pack-years (20–200)†
Median pCO ₂ (range)	45 mmHg (27–97, on 73 patients with admission blood gases)
Median APACHE II score (range)	20 (17–26)
Age points (range)	5 (2–6)
Chronic health points (range)	0 (0–5)
Glasgow coma score points (range)	15 (15–15)
Acute physiologic score points (range) (excluding Glasgow coma score)	3 (0–10)
Median length of stay (range)	4 days (0–54 days)
Alive at end of follow-up % (n)	48 (44)
Median time of observation (range)	3.5 years (2 days–4.6 years)

pCO₂, partial pressure of carbon dioxide.

* Of 85 patients with known smoking status.

† Of 83 patients with known smoking status.

A secondary analysis was performed to determine whether APACHE II could predict length of stay. We used all available covariates in the univariate analysis. We included qualifying variables in the multivariate analysis using the above-described algorithm.

Other secondary analyses were performed to determine the relative importance of APACHE II subsets or other predictors. One secondary analysis included only parts of the APACHE II to determine the relative importance of individual components. The three components of the APACHE II are age, APS, and chronic health. We tested the association of each component with long-term mortality using Cox regression. Another analysis determined the relative contributions of age, pCO₂ (a variable not included in the APACHE II), and smoking history with physiologic variables included in the APACHE II score in predicting mortality in both Cox and logistic models. STATA 7.0 was used for all statistical analyses (STATA Corp., College Station, TX).

RESULTS

The ICD-9 codes identified 277 patients. One hundred and one of them did not meet clinical criteria for COPD exacerbation. Twenty-four patients had x-ray evidence of another diagnosis, 12 had a prior history of asthma, and 8 did not have a smoking history. One patient did not have a Social Security number. Nineteen patients were transferred from other hospitals. Twenty patients were transferred to the ICU either on admission or during their hospitalization. The remaining 92 patients were included in the analysis of APACHE II scores and long-term mortality. One patient died during their hospitalization and one patient was discharged within 24 hours of admission. These patients were censored in the analysis of APACHE II scores and length of stay.

All patients had age, gender, comorbidity information, temperature, mean arterial pressure, heart rate, respiratory rate, and GCS information. Although all patients included in the analysis had a history of smoking, we could not determine the current smoking status of 7 patients, and 9 patients did not have a documented pack-year history. To determine the APS, several variables were needed: temperature, mean arterial pressure, heart rate, respiratory rate, oxygenation, arterial pH, sodium, potassium, creatinine, hematocrit, and white blood count. Serum bicarbonate was used if no admission ABG was available. Seventy-three patients had an admission ABG. Two patients had neither ABG nor serum bicarbonate. One patient had a missing sodium, and three patients had missing creatinines. All other lab values were recorded for all patients.

Table 1 lists the baseline characteristics of the study population. Of the 92 patients included in the study, APACHE II scores ranged from 17 to 26. We divided the cohort into tertiles: APACHE II score under 20 ($n = 22$), APACHE II score of 20 ($n = 44$), and APACHE II score over 20 ($n = 26$). Smoking history was dichotomized into less than 60 pack-years ($n = 38$) and 60 pack-years or more ($n = 45$). PCO₂ was divided into less than 60 mmHg ($n = 60$) and 60 mmHg or more ($n = 13$). Comorbidity was split into no comorbidity ($n = 40$) and any nonpulmonary comorbidity ($n = 52$).

The aim of our primary analysis was to determine the ability of APACHE II to predict long-term mortality in a cohort of COPD patients admitted to a general medical floor. The results using Cox regression are presented in Table 2. Using our 3-level APACHE II classification in univariate analysis, we found a hazard ratio (HR) of 1.76 (95% confidence intervals [CI], 1.16–2.65) for APACHE II score. Figure 1 is a Kaplan-Meier survival curve of the patients in each APACHE II score stratum. Four variables were included with APACHE II score in the multivariate analysis

Table 2. Predicting Long-term Mortality Using Cox Regression

Characteristics	Hazard Ratio (95% CI)	P Value
Univariate analysis (N = 92)		
3-level APACHE II score	1.76 (1.16 to 2.65)	.007
Male sex	0.60 (0.33 to 1.08)	.087
60 pack-years or more	1.53 (0.83 to 2.83)	.172
Current smoker	0.74 (0.40 to 1.36)	.329
pCO ₂ greater than or equal to 60 mmHg	2.31 (1.08 to 4.91)	.030
Any comorbidity	2.58 (1.36 to 4.88)	.004
Length of stay	1.00 (0.98 to 1.04)	.575
Multivariate analysis (N = 65)		
3-level APACHE II score	2.19 (1.27 to 3.80)	.001
Male sex	0.47 (0.21 to 1.03)	.060
60 pack-years or more	2.32 (1.08 to 4.97)	.030
pCO ₂ greater than or equal to 60 mmHg	2.68 (1.10 to 6.50)	.030
Any comorbidity	3.34 (1.46 to 7.60)	.004

pCO₂, partial presence of carbon dioxide.

(see Table 2). APACHE II score was independently associated with long-term mortality (HR 2.19, CI 1.27 to 3.80). Comorbidity, admission pCO₂, and a smoking history of 60 pack-years or more were also independently associated with long-term survival.

We repeated the analysis as a logistic regression to determine probability of death at 3 years. The results are listed in Table 3. APACHE II score was highly associated with death at 3 years (odds ratio [OR] 2.31; CI 1.24–4.30). Four variables were included with APACHE II score in the multivariate analysis. APACHE II score (OR 2.62; CI 1.12–6.16) was the only variable independently associated with death at 3 years.

We also modeled the association of APACHE II score and length of stay using Cox regression. APACHE II score was not associated with length of stay (HR 0.83, CI 0.60 to 1.14 in the multivariate analysis). Patients with an admission pCO₂ less than 60 mmHg were more likely to

Table 3. Predicting Mortality at 3 Years Using Logistic Regression

Characteristics	Odds Ratio (95% CI)	P Value
Univariate analysis (N = 92)		
3-level APACHE II score	2.31 (1.24 to 4.30)	.009
Male sex	0.57 (0.25 to 1.32)	.189
60 pack-years or more	1.84 (0.76 to 4.48)	.179
Current smoker	0.62 (0.25 to 1.51)	.290
pCO ₂ greater than or equal to 60 mmHg	4.18 (1.15 to 15.21)	.030
Any comorbidity	2.24 (0.95 to 5.28)	.065
Length of stay	1.01 (0.97 to 1.06)	.555
Multivariate analysis (N = 65)		
3-level APACHE II score	2.62 (1.12 to 6.16)	.027
Male sex	0.63 (0.20 to 2.01)	.436
60 pack-years or more	2.57 (0.77 to 8.57)	.124
pCO ₂ greater than or equal to 60 mmHg	4.04 (0.90 to 18.06)	.068
Any comorbidity	2.16 (0.68 to 6.84)	.190

pCO₂, partial presence of carbon dioxide.

stay in hospital longer than patients with an admission pCO₂ of 60 mmHg or greater (HR 0.51, CI 0.27 to 0.99 in the multivariate analysis).

We were interested in determining the most useful components of the APACHE II score for predicting long-term mortality for these patients. Initially, we determined the relative contribution of each APACHE II component. All 92 patients in our analysis had a GCS of 15, so we only modeled age, APS without GCS, and chronic health points using Cox regression. The results are shown in Table 4. Of the three components, age was the variable most strongly associated with long-term mortality in a multivariate model. Next, we chose physiologic variables most closely related to COPD to determine whether those variables were associated with long-term mortality using Cox regression. Based on clinical experience, we chose respiratory rate, pO₂, pCO₂,

FIGURE 1. Kaplan-Meier survival curve by APACHE II score category.**Table 4. Using Multivariate Analysis for Components of APACHE II and Long-term Mortality Using Cox Regression**

Characteristics	Hazard Ratio (95% CI)	P Value
Univariate analysis (N = 92)		
Age score	1.47 (1.09 to 1.99)	.011
Acute physiologic score (APS without GCS)	1.04 (0.93 to 1.17)	.450
Chronic health score	1.02 (0.68 to 1.52)	.939
Other potential predictors of long-term survival (N = 65)		
Respiratory rate score	1.02 (0.57 to 1.82)	.947
pO ₂ score	0.86 (0.68 to 1.09)	.214
pH score	0.56 (0.25 to 1.29)	.175
Age score	1.64 (1.10 to 2.46)	.016
pCO ₂ greater than or equal to 60 mmHg	4.40 (1.31 to 14.78)	.017
60 or more pack-years	2.38 (1.11 to 5.10)	.026
Any comorbidity	3.10 (1.37 to 7.05)	.007

pCO₂, partial presence of carbon dioxide.

FIGURE 2. Receiver operating characteristic curves to predict 3-year mortality using APACHE II score and age with significant covariates ($N = 65$).

pH, smoking history, comorbidity, and age. For variables included in the APACHE II, we used the same scoring system as APACHE II. Of the 65 patients included in this model, age, admission $p\text{CO}_2$, 60 or more pack-years, and comorbidity were significantly associated with long-term survival in a multivariate model.

We used influence statistics to evaluate the robustness of our model. In logistic regression, ΔB_j measures the standardized change in estimated parameters that results from deleting all cases with the j th covariate pattern.²² This measure is similar to Cook's D for linear regression. Of the 65 patients included in the multivariate logistic model, 2 patients had ΔB_j s of 1 or greater. After removing these two cases ($N = 63$), only APACHE II score, smoking history, and admission $p\text{CO}_2$ were associated with death at 3 years. The association between comorbidity and death at 3 years became insignificant (data not shown).

Finally, we compared the ability of the complete APACHE II score with only the age component of the APACHE II score to predict death at 3 years using receiver operating characteristics (ROC) curves. A ROC curve plots 1 specificity against sensitivity to determine the accuracy of the "test" to predict a dichotomous outcome. We combined APACHE II score with admission $p\text{CO}_2$, smoking history, and comorbidity to determine the ability of these variables to predict death at 3 years. We combined the same covariates with age (scored as in the APACHE II) and repeated the process. We combined age (scored as in the APACHE II) with admission $p\text{CO}_2$ and smoking history and repeated the process a third time. All three ROC curves are presented in Figure 2. The area under the curve for the APACHE II score plus covariates was 0.755. The areas under the curve for age plus covariates with and without comorbidity were both 0.750. The 3 curves were not statistically different (χ^2 test for equality of area under the curve, $P = .944$).

DISCUSSION

After controlling for relevant covariates, our results demonstrated a statistically significant association of APACHE II score and long-term survival in patients with COPD admitted to a general medical ward. The Cox regression model found smoking history, comorbidity, and admission $p\text{CO}_2$ to be independently associated with long-term mortality. These variables were not associated with death at 3 years in the logistic regression model. The logistic regression model only takes a snapshot of the survival curve at 1 point (i.e., 3 years), whereas the Cox regression model includes information across the entire study period. The additional information in the Cox regression model could explain the differences in the two analyses. The association between APACHE II and long-term mortality by two separate regression models strengthens our confidence in the study results.

The entire APACHE II may not be necessary for determining patients' prognosis. Of the components of the APACHE II score, the age component seems to be the most strongly associated with long-term mortality. Including smoking history and admission $p\text{CO}_2$ with the age subscore from APACHE II was as predictive of death at 3 years as the 3 variables combined with APACHE II score. This was a secondary analysis in our study, but this finding is worth exploring in future trials.

Our results compare favorably with other prognostic indices for hospitalized elderly patients. Walter et al. validated a prognostic tool utilizing gender, functional status at discharge, congestive heart failure, cancer, renal insufficiency, and low albumin in a large cohort of patients older than 70 years discharged from a general medical floor from a tertiary care hospital.²³ They used this tool to predict 1-year survival. The area under the ROC curve in their study was 0.79.

Other studies have deconstructed the APACHE successfully. Weingarten et al. found the GCS predicted inpatient mortality as well as APACHE II score among patients admitted for stroke.²⁴ Seneff et al. found the APACHE II's nonrespiratory component to be most strongly associated with inpatient and 6-month mortality among patients admitted to the ICU for COPD exacerbation.²⁵

Length of stay was not associated with APACHE II score in this cohort. Admission $p\text{CO}_2$ was weakly associated with length of stay. The variation in length of stay may be driven more by discharge logistics than the patient's medical condition. Placement in an extended care facility or arranging home health care may take several days after the patient has recovered from their COPD exacerbation. We do not expect these findings to be consistently replicated in future studies.

One extension of this work would be to determine the association of APACHE II score and ICU admission. Unfortunately, our data collection was focused on patients admitted to a general medical floor. Patients who are markedly dyspneic may be intubated without further evaluation.

It was unclear from our data collection whether the admission data were recorded before or after intubation for patients admitted to the ICU directly from the emergency room. Patients who are initially admitted to the general medical floor and then transferred to the ICU may represent a different phenomenon than patients admitted directly to the ICU. Researchers would need to consider these contingencies when designing studies to examine the relationship between admission presentation and ICU admission for patients admitted with a COPD exacerbation.

Our population of COPD patients does not reflect the range of APACHE II scores found in other studies. APACHE II scores in our study ranged from 17 to 26. In the original APACHE II study, the range of scores was from 0 to greater than 35.³ The Rubin study had an APACHE II score range of less than 10 to greater than 30.⁹ The study by Forrest et al. had a range of APACHE II scores of 13 to 35.⁸ Increasing the APACHE II score increases the probability of ICU admission. The narrow range of APACHE II scores could have limited the instrument's ability to predict ICU admission or length of stay. Despite this possible limitation, the instrument was still associated with long-term survival in our study.

Our mortality data are limited. The accuracy of the SSDI in recording death is unknown.²⁶ We are not aware of any work validating the SSDI in medical studies. Owing to its accessibility and low cost, other researchers have used the SSDI to determine long-term survival.^{19,20} In addition, we were unable to determine the cause of death for each patient in our study. Increased pulmonary-related mortality in patients with higher APACHE II scores would increase the face validity of this study.

FEV₁ was not available to us in this study. COPD patients may have pulmonary function testing carried out before a COPD exacerbation, but that information is not routinely available at admission. FEV₁ testing at time of COPD exacerbation is not recommended.¹⁶ Almagro et al. studied 135 patients admitted to a general medical floor for COPD exacerbation and found FEV₁ at hospital discharge was not associated with long-term mortality in their multivariate model including comorbidity, depression, and activity.²⁷

Patients in this study may not represent all COPD patients. This cohort lacked the racial variation seen in other parts of the country. Variations in COPD treatment patterns could also alter the results in different settings.

The APACHE II score was associated with long-term survival in patients admitted with COPD to a general medical floor in this cohort. Smoking history, admission pCO₂, and comorbidity have varying degrees of association with survival depending on the model examined. Age, smoking history, and admission pCO₂ could predict 3-year survival nearly as well as more complicated models. Our research suggests further work in developing prognostic instruments for patients admitted to general medical wards may be accomplished using easily obtained clinical and demographic variables.

We thank Marilee Jones, MAMC, for her editorial support.

REFERENCES

1. Reynolds T. Prognostic models abound, but how useful are they? *Ann Intern Med.* 2001;135:473–6.
2. Knaus WA, Zimmerman JE, Wagner DP, Draper EA, Lawrence DE. APACHE-acute physiology and chronic health evaluation: a physiologically based classification system. *Crit Care Med.* 1981;9:591–7.
3. Knaus WA, Draper EA, Wagner DP, Zimmerman JE. Apache II. A severity of disease classification system. *Crit Care Med.* 1985;13:818–29.
4. Jennet B, Teasdale G, Braakman R. Predicting outcome in individual patients after severe brain injury. *Lancet.* 1976;1:1031–4.
5. Ridley S, Jackson R, Findlay J, Wallace P. Long term survival after intensive care. *BMJ.* 1990;301:1127–30.
6. Roche VML, Kramer A, Hester E, Welsh CH. Long-term functional outcome after intensive care. *J Am Geriatr Soc.* 1999;47:18–24.
7. Berger R, Kelley M. Survival after in-hospital cardiopulmonary arrest of noncritically ill patients. *Chest.* 1994;106:872–9.
8. Forrest DM, Zala C, Djurdjev O, et al. Determinants of short- and long-term outcome in patients with respiratory failure caused by AIDS-related *Pneumocystis carinii* pneumonia. *Arch Intern Med.* 1999;159:741–7.
9. Rubin RA, Haskal ZJ, O'Brien CB, Cope C, Brass CA. Transjugular intrahepatic portosystemic shunting: decreased survival for patients with high APACHE II scores. *Am J Gastroenterol.* 1995;90:556–63.
10. El-Shahawy MA, Abging L, Badillo E. Severity of illness scores and the outcome of acute tubular necrosis. *Int Urol Nephrol.* 2000;32:185–91.
11. Afessa B, Morales LJ, Scanlon PD, Peters SG. Prognostic factors, clinical course, and hospital outcome of patients with chronic obstructive pulmonary disease admitted to an intensive care unit for acute respiratory failure. *Crit Care Med.* 2002;30:1610–5.
12. Breen D, Churches T, Hawker F, Torzillo PJ. Acute respiratory failure secondary to chronic obstructive pulmonary disease treated in the intensive care unit: a long term follow up study. *Thorax.* 2002;57:29–33.
13. American Thoracic Society. Standards for the diagnosis and care of patients with chronic obstructive pulmonary disease. *Am J Respir Crit Care Med.* 1995;152:S77–120.
14. Connors AF, Dawson NV, Thomas C, et al. Outcomes following acute exacerbation of severe chronic obstructive lung disease: the SUPPORT investigators (Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments). *Am J Respir Crit Care Med.* 1996;154:959–67.
15. 2001 Physician ICD, 9 CM. International Classification of Diseases 9th Revision Clinical Modification, 6th edn. Salt Lake City, UT: Medicode Publications; 2000.
16. Celli BR, Snider GL, Heffner J, et al. Standards for the diagnosis and care of patients with chronic obstructive pulmonary disease (COPD) and asthma. *Am Rev Respir Dis.* 1997;136:225–44.
17. Snow V, Lascher S, Mottur-Pilson C, et al. The evidence base for management of acute exacerbations of COPD: clinical practice guideline, part 1. *Chest.* 2001;119:1185–9.
18. Charlson ME, Pompei P, Ales KL, McKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chron Dis.* 1987;40:373–83.
19. Lipinski M, Froelicher V, Atwood E, et al. Comparison of treadmill scores with physician estimates of diagnosis and prognosis in patients with coronary artery disease. *Am Heart J.* 2002;143:650–8.
20. Jones JW, Schmidt SE, Miller CC III, Beall, AC, Jr, Baldwin JC. Bilateral internal thoracic artery operations in the elderly. *J Cardiovasc Surg* 2000;41:165–70.

21. Grambsch PM, Therneau TM. Proportional hazards tests and diagnostics based on weighted residuals. *Biometrika*. 1994;81:515–26.
22. Hamilton LC. Chapter 7: Logit regression. In: *Regression with Graphics: A Second Course in Applied Statistics*. Belmont, CA: Duxbury Press; 1992:238–42.
23. Walter LC, Brand RJ, Counsell SR, et al. Development and validation of a prognostic index for 1-year mortality in older adults after hospitalization. *JAMA*. 2001;285:2987–94.
24. Weingarten S, Bolus R, Riedinger MS, Maldonado L, Stein S, Ellrodt AG. The principle of parsimony: Glasgow coma scale score predicts mortality as well as the APACHE II score for stroke patients. *Stroke*. 1990;21:1280–2.
25. Seneff MG, Wagner DP, Wagner RP, Zimmerman JE, Knaus WA. Hospital and 1-year survival of patients admitted to intensive care units with acute exacerbation of chronic obstructive pulmonary disease. *JAMA*. 1995;274:1852–7.
26. Social Security Death Index FAQ. Available at: <http://www.ancestry.com/search/rectype/vital/ssdi/faq.htm#where>. Accessed October 28, 2002.
27. Almagro P, Calbo E, Ochoa de Echaguen A, et al. Mortality after hospitalization for COPD. *Chest*. 2002;121:1441–8.