Intensive Care Unit Admission With Community-Acquired Pneumonia

Adam S. Vohra, BA, Hyo Jung Tak, PhD, Maulin B. Shah, MA, David O. Meltzer, MD, PhD and Gregory W. Ruhnke, MD, MS, MPH

Abstract: *Background:* There has been a dramatic increase in the use of intensive care units (ICUs) over the past 25 years. Greater use of validated measures of illness severity may better inform ICU admission decisions in patients with community-acquired pneumonia. This article examined predictors of ICU admission and hospitalization costs, including the pneumonia severity index (PSI) and CURB-65 (confusion, uremia, respiratory rate, blood pressure, age ≥65 years) scores. *Methods:* The study identified 422 patients hospitalized for community-acquired pneumonia, ascertaining patient characteristics by chart review and extraction of administrative data. Multivariate logistic regression was performed to quantify the association of the PSI, CURB-65 and comorbidities with ICU admission. The predictors of cost were estimated using a generalized linear model. *Results:* Compared to 194 general medicine patients, certain clinical and radiographic findings were more common among 228 ICU patients. Compared to PSI reference group I/II/III, ICU admission was strongly associated with risk class IV (odds ratio [OR], 3.06; 95% confidence interval [CI], 1.63–5.72) and V (OR, 4.84; CI, 2.44–9.62), and also CURB-65 ≥3 (OR, 2.90; CI, 1.51–5.56). The relative increase in mortality among PSI risk class V (compared to IV) patients was 2.68 times higher in general medicine, compared with the ICU. Among ICU admissions, risk class V was associated with an additional cost of $14,548 (95% CI, $4,232 to $24,864). *Conclusions:* Illness severity and chronic pulmonary disease are strong predictors of ICU admission. More extensive use of the PSI may optimize site-of-care decisions, thereby minimizing mortality and unnecessary resource utilization.

Key Indexing Terms: Community-acquired pneumonia; Intensive care unit; Severity of illness; Pneumonia severity index; Hospitalization costs. **[Am J Med Sci 2015;350(5):380–386.]**

The use of intensive care units (ICUs) in the United States has greatly increased. Since 1985, there has been a large increase in the number of beds and hospital days accrued in ICUs, accompanied by a 328% rise in total costs incurred for critical care.[1,2] These expenses exceed $80 billion annually, comprising 13.4% of all inpatient costs.[3] Optimizing decisions regarding allocation of these scarce resources is important to maximize the health benefits achieved by these expenditures.[4,5]

Universal measurement of illness severity may better inform decisions regarding the necessity of ICU care and perhaps optimize the cost-effectiveness of critical care expenditures.[6] In the past 30 years, although there has been a significant decline in the length of stay (LOS) and mortality rate among patients with community-acquired pneumonia (CAP),[7–10] total costs have remained relatively constant because of markedly higher costs per hospitalization day.[7] Limiting discretionary and unnecessary ICU stays may provide an opportunity to reduce associated costs, thereby improving efficiency. Research has also shown, however, that patients with CAP who were admitted late to the ICU had a longer LOS and increased mortality than patients admitted to the ICU on the day of presentation to the hospital.[11] Therefore, clinical decision tools that accurately predict the need for ICU admission in real time may aid in site-of-care decisions for patients with CAP.

This study examined the extent to which severity of illness and comorbidities predict ICU admission and hospitalization costs. Specifically, the study examines the degree to which the pneumonia severity index (PSI)[12] and the British Thoracic Society's CURB-65 (confusion, uremia, respiratory rate, blood pressure, age ≥65 years) scores, the most well-validated tools for assessing mortality risk among patients with CAP, predict ICU admission. Despite strong evidence supporting the use of the PSI to identify patients with a low risk of mortality,[13–16] recent evidence has suggested that it has limited utility in predicting the likelihood of ICU admission.[17] Although researchers have sought to identify additional predictors of ICU admission,[18–20] this study reexamined the ability of these existing tools, along with other variables, to predict ICU admission in an urban population. The few studies that have investigated predictors of ICU admission[21–24] have not compared the PSI and the CURB-65. A better understanding of ICU admission decisions may provide information critical for reducing mortality and maximizing efficient allocation of resources in the care of patients with CAP.[22–24]

METHODS

Study Design and Population

This observational study examined a sample of patients admitted to the University of Chicago Medical Center from 2002 to 2011. Adult patients were selected using a published algorithm to accurately identify patients admitted for CAP to minimize misclassification.[9,25–27] Subjects either had a principal diagnosis of pneumonia (*International Classification of Disease, Ninth Revision, Clinical Modification* [*ICD-9-CM*] codes 481–486) or a pneumonia secondary diagnosis with a principal diagnosis of sepsis (*ICD-9-CM* codes 038, 995.92, 995.91, 785.52) or respiratory failure (*ICD-9-CM* codes 518.81, 518.82, 518.84, 799.1).[26] Within this group of patients, a sample of ICU patients was matched with general medicine patients using a propensity score created by a logistic regression model predicting mortality based on age, sex and comorbidities created from discharge diagnoses according to the Elixhauser comorbidity software.[28]

From the Department of Medicine (ASV), Pritzker School of Medicine, University of Chicago, Chicago, Illinois, Department of Medicine (DOM, GWR), Section of Hospital Medicine, University of Chicago, Chicago, Illinois, Department of Health Management and Policy (HJT), University of North Texas Health Science Center, Fort Worth, Texas; and University of Pittsburgh School of Medicine (MBS), Pittsburgh, Pennsylvania.

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Correspondence: Adam S. Vohra, BA, Department of Medicine, Pritzker School of Medicine, University of Chicago, 5841 South Maryland Avenue, MC5000, Chicago, IL 60637 (E-mail: avohra@uchicago.edu).

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Data Collection

Charts were abstracted to calculate the PSI[12] and CURB-65[29] at presentation. The PSI includes age, sex, nursing-home residence, coexisting illnesses (neoplastic disease, liver disease, congestive heart failure [CHF], cerebrovascular disease and renal disease), mental status, vital signs and laboratory and radiological findings (arterial pH, blood urea nitrogen, sodium, glucose, hematocrit, partial pressure oxygen and the presence of pleural effusion). Patients were classified according to PSI risk class[12] and CURB-65 scores.[29]

Administrative data were also collected: age, sex, LOS, total costs, discharge diagnoses and procedures (mechanical ventilation *ICD*-9 codes 96.71 and 96.72). Using the Elixhauser Comorbidity Software, 29 binary comorbidity variables were defined based on patients' secondary discharge diagnoses.[28] For those pre-existing comorbidities ascertained during chart review, this designation was used instead of the Elixhauser comorbidity designation.

Statistical Analysis

Patients were compared by site of care according to baseline characteristics, clinical findings, and also PSI and CURB-65 scores. Continuous and categorical variables were compared using Student's t test and χ^2 analysis, respectively. A linear relationship between PSI and ICU admission likelihood made the use of PSI as a continuous variable permissible. ICU admission likelihood was then estimated using multivariate logistic regression models that included PSI as a continuous variable and, separately, as binary categorical variables indicating risk class (I, II and III were combined for consistency with the previous literature[21] and to create 3 groups of similar size) and comorbidities not included in the PSI. PSI component data elements (age, sex and certain comorbidities) were not entered as separate variables. Multivariate logistic regression was also performed estimating ICU admission likelihood according to CURB-65 score, controlling for sex and comorbidities. CURB-65 was specified as 3 binary categorical variables (CURB-65 score, 0/1, 2 and ≥3) consistent with the previous literature.[6]

In univariate logistic regressions of ICU admission on each comorbidity indicator variable, HIV, arthritis and blood loss were paradoxically associated with a reduced chance of ICU admission. They were thus excluded from the multivariate model because such a relationship has been shown to reflect coding bias.[30]

Median hospitalization costs were calculated by PSI risk class. All costs were adjusted to 2007 dollars using the consumer price index.[31] The impact of PSI risk class and comorbidities on cost among ICU patients was estimated based on a generalized linear model with cost as the dependent variable, using a γ distribution and a log-link function.[32] Because of

TABLE 1. Patient characteristics

Characteristics	Site of care: General medicine (N = 194)	Site of care: Intensive care unit (N = 228)
Demographic		
Age (mean)	60.3	61.3
18–52 (tertile 1)	73 (37.6)	73 (32.0)
53–72 (tertile 2)	56 (28.9)	85 (37.3)
≥72 (tertile 3)	65 (33.5)	70 (30.7)
Female sex	109 (56.2)	109 (47.8)
Nursing-home residence	15 (7.7)	18 (7.9)
Clinical		
Coexisting illnesses		
Coronary artery disease	44 (22.8)	39 (17.1)
Congestive heart failure	40 (20.6)	51 (22.4)
Chronic pulmonary disease	37 (19.1)	79 (34.7)[a]
Cerebrovascular disease	29 (15.0)	33 (14.5)
HIV/AIDS	18 (9.3)	5 (2.2)[b]
Transplanted organ	9 (4.6)	16 (7.0)
Neoplastic disease	41 (21.1)	50 (21.9)
Renal disease	41 (21.1)	47 (20.6)
Liver disease	15 (7.7)	15 (6.6)

Data are given as no. (%) unless otherwise indicated.
[a] $P < 0.001$ versus general medicine.
[b] $P < 0.01$ versus general medicine.

TABLE 2. Symptoms, signs and radiographic findings

Characteristics	Site of care: General medicine (N = 194)	Site of care: Intensive care unit (N = 228)
Clinical		
Symptoms		
Chest pain	79 (40.7)	59 (25.9)[b]
Cough	162 (83.5)	123 (54.0)[a]
Fatigue	71 (36.6)	92 (40.4)
Fever	124 (63.9)	109 (47.8)[b]
Hemoptysis	24 (12.4)	16 (7.0)
Loss of appetite	47 (24.2)	49 (21.5)
Shortness of breath	140 (72.2)	184 (80.7)[c]
Sputum production	113 (58.2)	85 (37.3)[a]
Signs		
Respiratory rate ≥30 per minute	19 (9.8)	53 (23.3)[a]
Heart rate ≥125 per minute	26 (13.4)	72 (31.6)[a]
Systolic blood pressure <90 mm Hg	7 (3.6)	35 (15.4)[a]
Altered mental status	34 (17.5)	91 (39.9)[a]
Radiographic findings		
Pneumonia findings		
Infiltrate	6 (3.1)	6 (2.6)
Air space disease	38 (19.6)	72 (31.6)[b]
Opacification	103 (53.1)	135 (59.2)
Consolidation	44 (22.7)	50 (21.9)
Congestive heart failure/edema	48 (24.7)	90 (39.5)[b]
Pleural effusion	71 (36.6)	84 (36.8)
Laboratory findings		
Glucose ≥250 mg/dL	8 (4.1)	34 (14.9)[a]
Sodium <130 mmol/L	15 (7.7)	23 (10.1)
Blood urea nitrogen ≥30 mg/dL	46 (23.7)	103 (45.2)[a]
Hematocrit <30%	32 (16.5)	51 (22.4)

Data are given as no. (%) unless otherwise indicated.
[a] $P < 0.01$ versus general medicine.
[b] $P < 0.001$ versus general medicine.
[c] $P < 0.05$ versus general medicine.