CHEST

Hospital-Level Variation in ICU Admission and Critical Care Procedures for Patients Hospitalized for Pulmonary Embolism

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BACKGROUND: Variation in the use of ICUs for low-risk conditions contributes to health system inefficiency. We sought to examine the relationship between ICU use for patients with pulmonary embolism (PE) and cost, mortality, readmission, and procedure use.

METHODS: We performed a retrospective cohort study including 61,249 adults with PE discharged from 263 hospitals in three states between 2007 and 2010. We generated hospital-specific ICU admission rate quartiles and used a series of multilevel models to evaluate relationships between admission rates and risk-adjusted in-hospital mortality, readmission, and costs and between ICU admission rates and several critical care procedures.

RESULTS: Hospital quartiles varied in unadjusted ICU admission rates for PE (range, ≤15% to >31%). Among all patients, there was a small trend toward increased use of arterial catheterization (0.6%-1.1%, $P < .01$) in hospital quartiles with higher levels of ICU admission. However, use of invasive mechanical ventilation (14.4%-7.9%, $P < .01$), noninvasive ventilation (6.6%-3.0%, $P < .01$), central venous catheterization (14.6%-11.3%, $P < .02$), and thrombolytics (11.0%-4.7%, $P < .01$) in patients in the ICU declined across hospital quartiles. There was no relationship between ICU admission rate and risk-adjusted hospital mortality, costs, or readmission.

CONCLUSIONS: Hospitals vary widely in ICU admission rates for acute PE without a detectable impact on mortality, cost, or readmission. Patients admitted to ICUs in higher-using hospitals received many critical care procedures less often, suggesting that these patients may have had weaker indications for ICU admission. Hospitals with greater ICU admission may be appropriate targets for improving efficiency in ICU admissions. CHEST 2014; 146(6):1452-1461

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ABBREVIATIONS: FTE = full-time equivalent; ICD-9-CM = *International Classification of Diseases, Ninth Revision, Clinical Modification*; PE = pulmonary embolism; POA = present on admission; SID = state inpatient database

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As health-care spending continues to rise, policymakers are actively seeking ways to maximize quality while reducing cost and inefficiency.[1] ICUs are an important focus for such efforts because of their significant costs and high staffing requirements.[2,3] Wide variation in ICU admission practice across hospitals suggests an opportunity to improve the efficiency in the use of this expensive resource.[4-7]

Aggressive ICU admission practices, however, can only be deemed inefficient to the extent that they do not improve outcomes.[8,9] Studies of patients with heterogeneous diagnoses along with studies limited to specific diseases have revealed significant hospital-level variability in ICU use without differences in mortality.[4] Little is known, however, about how ICU use impacts outcomes other than mortality, such as cost or readmission, or how liberal ICU admission practices affect rates of invasive procedures that may contribute to downstream complications.[10-13] Such issues are important for determining whether high ICU-use hospitals are overusing ICU beds or are providing appropriately aggressive care.

To examine the impact of hospital-level variability in ICU use on mortality, readmissions, and costs of care, we used discharge data in three states for patients with discharge diagnoses of pulmonary embolism (PE). PE serves as a representative example of a potentially discretionary ICU admission because it is common, often low risk, and can be cared for in a variety of settings.[14-16] To understand potential mechanisms of how variability in ICU use of PE may impact outcomes, we then examined rates of selected invasive procedures across quartiles of ICU use.

Materials and Methods

Data Source and Study Population

We conducted a retrospective cohort study using hospital discharge records from North Carolina, New York, and Washington between January 1, 2007, and December 31, 2010. Data were obtained from the Healthcare Cost and Use Project's state inpatient databases (SIDs) from the Agency for Healthcare Research and Quality.[17] The SIDs data include nearly 100% of discharges from > 1,000 nonfederal hospitals in 46 states. Data are included for all patients independent of payer. Data on hospital characteristics were obtained from the American Hospital Association's Annual Survey from 2007 to 2010.[18]

We identified all adults (age ≥ 18 years) discharged from acute care hospitals with a primary discharge diagnosis of PE as defined by *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes 415.11, 415.19, and 673.2.[19,20] To ensure that included patients had PE as their admission diagnosis, we examined present on admission (POA) rates for the primary diagnosis field.[21] Among the states we included that released POA codes to the SIDs (New York and Washington), > 98% of primary discharge diagnoses of PE were marked POA (data not shown).

We excluded hospitals without ICU beds or missing data on ICU beds. We also excluded hospitals with < 25 PE hospitalizations over the study period to improve the reliability of hospital-based estimates.

Study Variables

ICU Admission Rates: For each hospital, we identified the proportion of hospitalizations with PE admitted to an ICU using the presence of ICU- or coronary care unit-specific room and board charges present among revenue codes. We excluded intermediate care ICUs from this definition.

Outcomes: Our primary risk-standardized outcomes included hospital-level mortality, readmission, and costs. We defined mortality as death during the index hospitalization, readmission as readmission to any acute care hospital within 30 days of discharge after the index hospitalization, and costs as the total reported hospital charges (adjusted for inflation to 2010 dollars) multiplied by the hospital-specific all-payer cost-to-charge ratio for the year of hospitalization.[22] We calculated these outcomes among two populations: (1) all patients with PE and (2) the subset of these patients with ICU stays.

Critical Care Therapies: For each hospital, we calculated the use of critical care therapies, again among all patients and the subset of patients with ICU stays. We used ICD-9-CM codes to identify selected therapies, including invasive mechanical ventilation (96.70-96.72), noninvasive mechanical ventilation (93.90), pulmonary artery catheterization (89.63, 89.64, 89.66-89.68), central venous catheterization (38.93), arterial catheterization (38.91 and 89.61), and use of thrombolytics (99.10).[23]

Adjustment Variables: Adjustment variables included demographic data (age, sex, and payer); admission data (weekday or weekend, emergent or nonemergent, admission source); individual patient comorbidities (as defined by Elixhauser et al[24]); presence of organ failure using ICD-9-CM codes corresponding to circulatory, renal, neurologic, hematologic, metabolic, and hepatic organ failure (as defined by Angus et al[25]); use of ICU procedures (central line, arterial line, pulmonary artery catheterization, thrombolytics, invasive mechanical ventilation, and noninvasive positive pressure ventilation); hospital size; total hospital-wide patients with PE across the study period; ICU capacity (as a percentage of total beds); teaching status (defined by the ratio of resident full-time equivalents [FTEs] to beds); medical school affiliation; designation as a critical access hospital; and hospital type (for profit, not for profit, or government). Race and ethnicity were omitted because these data were missing for many of the patients included in the study.

Statistical Analysis

We estimated hospital-specific rates of ICU admission using empirical Bayes posterior estimates from an empty multilevel logistic regression model, where individual hospitalizations were nested within hospitals. This approach accounts for the poor reliability of ICU admission rates calculated from hospitals with few cases.[26] We divided hospitals and their patients into quartiles by ICU admission rate and compared patient and hospital characteristics across these quartiles using nonparametric tests for trend. Quartile 1 contained hospitals with the lowest rates of ICU use for PE.

We entered ICU admission rate quartile into a series of multilevel models to estimate its relationship with risk-adjusted in-hospital mortality, readmission, and cost. Finally, we used logistic regression accounting for clustering by hospitals to evaluate the relationship between ICU admission rate quartile and use of each ICU therapy among all patients and the subgroup of patients admitted to the ICU.[27] Predictive margins were