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Original Research

PULMONARY EMBOLISM

Recent Trends in Clinical Outcomes and Resource Utilization for Pulmonary Embolism in the United States

Findings From the Nationwide Inpatient Sample

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Background: **Pulmonary embolism (PE) has been cited as the most common preventable cause of death in hospitalized patients. The objectives of this study were to determine recent trends in clinical outcomes and resource utilization for hospitalized patients with a clinically recognized episode of acute PE.**

Methods: **Patients with primary or secondary PE who had been discharged from US acute care hospitals were identified from the Nationwide Inpatient Sample during the 8-year period between 1998 and 2005. The major clinical outcomes assessed included hospital mortality and length of hospitalization. To assess resource utilization for the treatment of PE, average hospital charges for these admissions were assessed, normalized to 2005 US dollars, and adjusted to reflect the US consumer price index.**

Results: **Between 1998 and 2005, the number of patients with primary or secondary PE on discharge from the hospital increased from 126,546 to 229,637; hospital case fatality rates for these patients decreased from 12.3 to 8.2% ($p < 0.001$); length of hospital stay decreased from 9.4 days to 8.6 days ($p < 0.001$); and total hospital charges increased from \$25,293 to \$43,740 ($p < 0.001$).**

Conclusions: **Between 1998 and 2005, significant improvements were observed in outcomes for patients hospitalized for clinically recognized PE, including decreases in mortality and length of hospital stay. Charges for this hospital care increased during this time period.**

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Abbreviations: ICD-9 = *International Classification of Diseases*, ninth revision; NIS = Nationwide Inpatient Sample; PE = pulmonary embolism; VTE = venous thromboembolism

Pulmonary embolism (PE) is a leading cause of mortality and morbidity in hospitalized patients in the United States. Between 5% and 10% of hospital deaths are attributable to PE,[1–3] leading to an estimated 100,000 to 200,000 deaths annually in the United States from PE.[4–6] Because prophylaxis is clinically effective and cost-effective,[7–9] PE is the most common preventable cause of death in hospitalized patients.[7]

Contemporary studies estimate that annual healthcare expenditures related to venous thromboembolism

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(VTE) and PE are in excess of $1.5 billion.[10] At the individual patient level, hospital costs incurred by patients in whom VTE complications develop are double those for patients in whom these complications do not develop.[11] Several advisory groups[12–16] have sponsored initiatives to require all hospitalized patients to be assessed for VTE risk and to have appropriate thromboprophylaxis administered. Despite these efforts, the use of prophylaxis remains unacceptably low for several high-risk groups of patients. In particular, multiple studies[17,18] have demonstrated disparities between surgical and nonsurgical patients in terms of the use of appropriate prophylaxis. These findings highlight the necessity to continue to evaluate the clinical impact of PE on hospitalized surgical and nonsurgical patients and to determine the impact of nationwide initiatives to increase the use of VTE prophylaxis. The objectives of the present study were to determine the recent trends in clinical outcomes and resource utilization for patients hospitalized with a clinically recognized episode of acute PE in the United States.

Materials and Methods

Data used in this study were obtained from the Nationwide Inpatient Sample (NIS), from the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality. This database contains information abstracted from approximately 8 million patient hospitalizations per year and comprises a stratified sampling frame of 20% of all US hospital discharges. These data can be used to produce a weighted estimate of approximately 35 to 39 million patient hospitalizations per year. All patient identifiers have been removed from this database. The NIS represents the largest all-payer inpatient care database available and provides the unique opportunity to estimate nationwide trends for hospital admissions related to specific diseases and their associated clinical outcomes.[19,20] Data used for this analysis were adjusted national estimates based on the stratified sampling frame of discharges. The total number of weighted discharges per year reflected in the NIS database were as follows: 34,874,046 Data processing and statistical ana (1998); 35,467,673 (1999); 36,417,565 (2000); 37,187,641 (2001); 37,804,021 (2002); 38,220,659 (2003); 38,661,786 (2004); and 39,163,834 (2005). The NIS database was queried for an 8-year period from January 1, 1998, to December 31, 2005, for patients discharged with primary or secondary PE. These patients were defined according to the *International Classification of Diseases*, ninth revision (ICD-9), clinical modification codes that correspond to PE (415.11 to 415.19). The total cohort was further stratified according to surgical or nonsurgical hospital discharge status to permit comparison between subgroups. Surgical patients were identified using the ICD-9 clinical modification procedure codes 01 to 86.99, which pertain to major surgical procedures. Codes for minor procedures were excluded, using a method described previously.[21]

The total cohort, together with surgical and nonsurgical subgroups, was assessed for baseline characteristics, including age, gender, ethnicity, and type of hospital admission (*eg*, emergency, urgent, or elective). The analysis of patients' baseline characteristics was performed to determine whether certain subgroups of patients with PE were more high risk, therefore skewing the results of our comparisons of clinical outcomes and resource utilization. Recognized risk factors for PE were assessed, including malignancy, previous VTE, obesity (body mass index > 30 kg/m^2), hormone-replacement therapy, congestive heart failure, prior stroke, coronary artery disease, nonambulatory status, smoking history, comorbid lupus, recent infection, recent hip or long-bone fracture, and clinically reported varicose veins.[12–16]

The groups were assessed for specific clinical outcomes related to their current hospital admission, including in-hospital mortality, average length of stay, major bleeding (*ie*, hemorrhage leading to hemodynamic instability or requiring blood transfusion), and the incidence of heparin-induced thrombocytopenia. Relative resource utilization per hospital admission was estimated using mean hospital charges per PE-related hospital admission. Charges were normalized to 2005 US dollars adjusted to reflect the US consumer price index. Additional analyses were performed to determine whether surgical and nonsurgical patients were at differential risk for adverse outcomes or higher resource utilization. This study was conducted in full compliance with institutional review board policies for clinical research at the University of Massachusetts Medical School (Worcester, MA) and in compliance with rules for data use stipulated by the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality in granting the authors access to NIS data.[19,20]

Statistical Analysis

Data were analyzed and compared using analysis of variance for continuous data and χ^2 tests for proportions. Variables with a $p \leq 0.05$ were considered statistically different. Variables that were significantly different between comparison groups underwent further *post hoc* testing with a Student-Newman-Keuls test. Data processing and statistical analyses were performed with statistical software (SAS, version 9.1; SAS Institute, Inc; Cary, NC).

Results

Study Population

The study population comprised 1,378,670 patients of whom 397,188 (28.8%) were categorized as surgical and 981,482 (71.2%) as nonsurgical. These data represent national estimates extrapolated from the sampling frame of 20% of US hospitals. The estimated number of patients with primary or secondary PE discharged from the hospital each year increased from 126,546 in 1998 to 229,637 in 2005 (Fig 1). Of these discharges in 1998, 72,221 (57%) were given a primary discharge diagnosis of PE and 54,325 (43%) a secondary discharge diagnosis of PE. By 2005, 137,451 (60%) were discharged with primary PE and 92,186 (40%) with secondary PE. Nonsurgical patients accounted for a greater proportion of hospital admissions throughout the study, with 70 to 72% of discharges occurring among nonsurgical patients (Fig 1).

Both overall and in the two subgroups, the proportion of white patients decreased, whereas the proportion of African-American patients remained nearly constant (Table 1). The rates of elective hospital admissions decreased, whereas hospital admission rates from the emergency department increased ($p < 0.001$ in all three groups) [Table 1].