Venous Thromboembolism According to Age

The Impact of an Aging Population

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Background: With the aging of the US population, there is concern that the rate of venous thromboembolism will increase, thereby increasing the health burden. In this study we sought to determine trends in the diagnosis of deep venous thrombosis (DVT) and pulmonary embolism (PE) in the elderly as well as the use of diagnostic tests.

Methods: Data from the National Hospital Discharge Survey were used. These data are abstracted each year from a sample of records of patients discharged from non-federal short-stay hospitals in the entire United States. Main outcome measures were trends in rates of diagnosis of DVT and PE as well as trends in the use of diagnostic tests between 1979 and 1999.

Results: The rates of diagnosis of DVT and PE and of the use of diagnostic tests over 21 years were markedly higher in elderly than in younger patients (P<.001). Although the rate of diagnosed DVT in elderly patients strikingly increased over the past decade (P<.001), that of PE has been relatively constant. There was a proportionately greater use of venous ultrasonography, ventilation-perfusion lung scanning, and pulmonary angiography in elderly than in younger patients.

Conclusions: Extensive use of diagnostic tests in elderly patients in the past decade has resulted in an increased diagnostic rate for DVT but not PE. The reason for this disparity is uncertain but may reflect early diagnosis and treatment of DVT. With the aging of the population, DVT will increase the health burden.

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DATA SOURCES

Data from the NHDS were used for this study. The NHDS database is described in detail elsewhere. The survey design, sampling, and estimation procedures were planned to produce calendar-year estimates. Trained medical personnel coded diagnoses and procedures using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). A minimum of 1 and a maximum of 7 diagnostic codes were assigned for each sample abstract. If an abstract included surgical and/or diagnostic procedures, a maximum of 4 procedure codes was assigned.

NHDS SAMPLING SCHEME

The NHDS is based on a national probability sample of patients discharged from short-stay hospitals—exclusive of federal, military, and Department of Veterans Affairs hospitals—located in the 50 States and the District of Columbia. The sampling plan, performed in 3 stages, is described elsewhere.

ESTIMATION PROCEDURES

Estimates of patients with DVT and PE and the total number of diagnostic tests performed in the entire United States for DVT and PE were derived from the number of sampled patients with DVT and/or PE and the number of diagnostic tests performed in sampled patients using a multistage estimation procedure. This procedure, which produces essentially unbiased national estimates, is described elsewhere.

IDENTIFICATION OF DVT CASES

All available diagnostic code fields were screened for specific codes to identify patients with DVT and/or PE. Since 1979, the ICD-9-CM has been used for classifying diagnoses and procedures in the NHDS. Although the ICD-9-CM is modified annually, the diagnostic codes for “PE and infarction” and “phlebitis and thrombophlebitis of deep vessels of lower extremities” have changed little.

The specific ICD-9-CM codes that we used for identification of patients with PE were 415.1, 634.6, 635.6, 636.6, 637.6, 638.6, and 673.2. The codes used for identification of patients with DVT were 451.1, 451.2, 451.8, 451.9, 453.2, 453.8, 453.9, 671.3, 671.4, and 671.9. Five-digit codes, such as 451.11 (included under the code 451.1), were not listed because they were included under the corresponding 4-digit codes. The ICD-9-CM codes used for diagnostic tests were the following: 88.77 for diagnostic ultrasound examination of the peripheral vascular system (DVT ultrasonic scanning); 88.43 for arteriography of pulmonary arteries; 88.66 for venography of the lower extremities; and 92.15 for pulmonary radioisotopic scanning.

CALCULATION OF RATES OF DVT AND PE

We calculated the rates of DVT and PE in the general population. The population estimates were derived from the US Bureau of the Census estimates of national, state, and county resident populations. Estimated populations according to age and projected population estimates were obtained from the Centers for Disease Control and Prevention CDC WONDER database.

STATISTICAL ANALYSIS

The rates of diagnosis of DVT and PE were calculated by dividing the number of individuals having the conditions in a given period by the sum of the yearly census estimates of the US population in the same period and reporting the number per 100000 population. The numerator was obtained from the NHDS. The denominator was obtained from estimates based on the US census, as described. Yearly rates of diagnosis of DVT and PE were calculated for the 21-year period of observation. Descriptive statistics were used to graphically display trends over time in rates of diagnosis of DVT and PE and rates of use of diagnostic tests. These data show estimated rates of diagnosis or rates of use of diagnostic tests based on sampling rather than on a census of cases or procedures.

Linear regression analyses were performed to calculate the slopes of selected segments of the curves describing the data. Pearson correlation analyses were performed for the same linear segments to assess the extent of dispersion of points around the regression lines. More complex equations were used to describe the curves that related rate ratios for DVT and PE to age. Linear regression analyses were performed using InStat software, version 3.0 (GraphPad Software, San Diego, Calif), and nonlinear analyses were performed using SPSS software, version 11.0 (SPSS Inc, Chicago, Ill).

TRENDS IN THE RATE OF DVT DIAGNOSIS

Trends for the 21-year study period show that the rate of diagnosis of DVT in elderly patients (≥70 years) was constant from 1979 to 1990 but increased markedly from 1990 to 1999. The rate of DVT diagnoses was higher for elderly patients (≥70 years) than for younger patients (20-69 years old) (rate ratio, 4.72; 95% confidence interval, 4.30-5.14; P < .001) (Figure 1A). The rate of DVT diagnoses among elderly patients increased from 454 per 100000 population in 1990 to 655 per 100000 population in 1999 (Figure 1A).

The 21-year trends for diagnosing DVT according to age distribution (by 10-year increments) are shown in Figure 1B. The greatest use of diagnostic tests during the past decade occurred among the elderly population.

TRENDS IN THE RATE OF PE DIAGNOSIS

Trends for the 21-year study period show that the rate of PE diagnosis was greater among elderly patients (≥70 years) than among younger patients (20-69 years old) (rate ratio, 6.20; 95% confidence interval, 5.74-6.65; P < .001) (Figure 2A). Among elderly patients, the rate of PE diagnosis decreased from 370 per 100000 population in 1979 to 254 per 100000 population in 1990 (Figure 2A). From 1990 to 1999, the rate was constant among those
Deep venous thrombosis (DVT) per 100,000 population. A, Among elderly patients (≥70 years), the rate of diagnosis of DVT was constant from 1979 to 1990 and increased from 1990 to 1999 (slope=25.1 DVT per 100,000 population yearly; r=0.929; P<.001). In younger patients (20-69 years old), there was a slight but significant decline in the DVT rate between 1979 and 1990 (slope=−3.46 DVT per 100,000 population yearly; r=−0.911; P<.001); the rate then increased somewhat between 1990 and 1999 (slope=3.71 DVT per 100,000 population yearly; r=0.916; P<.001). B, From 1979 to 1990 the rate of diagnosis of DVT was constant in patients aged 60 to 69 years and 70 to 89 years. During this period the rate decreased in younger age groups (P=.01 to P<.001), and from 1990 to 1999 the rate increased in all age groups (P=.02 to P<.001).

70 years or older whereas it declined significantly among younger patients (20-69 years old), from 67 PE diagnoses per 100,000 population in 1979 to 30 per 100,000 population in 1990.

From 1979 to 1990, the rate of PE diagnosis decreased in all age groups (Figure 2B). From 1990 to 1999, it was constant in all age groups but 1—that of patients aged 20 to 39 years, for which it increased slightly.

Figure 2. Pulmonary embolism (PE) per 100,000 population. A, Among elderly patients (≥70 years), the rate of diagnosis of PE decreased from 1979 to 1990 (slope=−12.4 PE per 100,000 population yearly; r=−0.889; P<.001) and then remained constant from 1990 to 1999. In younger patients (20-69 years old) there was a slight but significant decline in the PE rate between 1979 and 1990 (slope=−3.06 PE per 100,000 population yearly; r=−0.946; P<.001); the rate then increased somewhat from 1990 and 1999 (slope=0.996 PE per 100,000 population yearly; r=0.847; P=.002). B, In all age groups the rate of diagnosis of PE significantly decreased from 1979 to 1990 (P=.01 to P<.001). From 1990 to 1999, the rates remained constant in all age groups except in the 20- to 39-year-old age group, whose rate increased slightly.

The rates of diagnosis of DVT or PE were similar for elderly men and women and for elderly blacks and whites. Trend analysis shows similar diagnostic rates during the 21-year interval. Covariate analysis for race and sex shows no effect of race (black or white) or sex on the increasing rate of DVT in the elderly.

INFLUENCE OF SEX AND RACE

The use of contrast venography of the lower extremities was higher in elderly than in younger patients (P<.001) (Figure 3). Venography use sharply declined from the late 1980s to the late 1990s, as the use of ultrasoundography increased.

Between 1989 and 1999, when venous ultrasonography of the lower extremities was commonly available, many more venous ultrasound tests of the lower extremities were performed in the elderly population (≥70 years) than in the younger population (20-69 years old) (rate ratio, 5.72; 95% confidence interval, 5.70-5.75; P<.001) (Figure 4A).

The rate ratio of the use of ultrasound tests, obtained by comparing the rate for each age decade with the rate for the group aged 20 to 29 years (based on mean 1989-1999 values), was highest in elderly patients (Figure 4B). The rate of use of lung scans for the 21-year study period was highest in elderly patients (P<.001) (Figure 5A). However, lung scan use declined in all age groups as Doppler ultrasonography became common.

The rate of pulmonary angiography for the 21-year study period was higher in elderly than in younger patients (P<.001) (Figure 5B). Pulmonary angiography use increased from 1979 to 1999 for both elderly and younger patients.

Figure 3. Venography of the lower extremities. A, From 1979 to 1990 the rate of use of venography for the group aged 20 to 29 years (based on mean 1989-1999 values), was highest in elderly patients (Figure 4B). The rate of use of lung scans for the 21-year study period was highest in elderly patients (P<.001) (Figure 5A). However, lung scan use declined in all age groups as Doppler ultrasonography became common.

Figure 4. Pulmonary angiography. A, From 1979 to 1990 the rate of use of pulmonary angiography for the group aged 20 to 29 years (based on mean 1989-1999 values), was highest in elderly patients (Figure 4B). The rate of use of lung scans for the 21-year study period was highest in elderly patients (P<.001) (Figure 5A). However, lung scan use declined in all age groups as Doppler ultrasonography became common.

Figure 5. Lung scans. A, From 1979 to 1990 the rate of use of lung scans for the group aged 20 to 29 years (based on mean 1989-1999 values), was highest in elderly patients (Figure 4B). The rate of use of lung scans for the 21-year study period was highest in elderly patients (P<.001) (Figure 5A). However, lung scan use declined in all age groups as Doppler ultrasonography became common.

Figure 1. Deep venous thrombosis (DVT) per 100,000 population. A, Among elderly patients (≥70 years), the rate of diagnosis of DVT was constant from 1979 to 1990 and increased from 1990 to 1999 (slope=25.1 DVT per 100,000 population yearly; r=0.929; P<.001). In younger patients (20-69 years old), there was a slight but significant decline in the DVT rate between 1979 and 1990 (slope=−3.46 DVT per 100,000 population yearly; r=−0.911; P<.001); the rate then increased somewhat between 1990 and 1999 (slope=3.71 DVT per 100,000 population yearly; r=0.916; P<.001). B, From 1979 to 1990 the rate of diagnosis of DVT was constant in patients aged 60 to 69 years and 70 to 89 years. During this period the rate decreased in younger age groups (P=.01 to P<.001), and from 1990 to 1999 the rate increased in all age groups (P=.02 to P<.001).

Diagnosis of DVT and PE according to age

Comparing the rates of diagnosis of DVT at each decade of age with the rate for those aged 20 to 29 years, the rate
ratio increased exponentially up to age 89 years (Figure 6A). In patients aged 70 to 79 years and 80 to 89 years, the rate ratios for diagnosis of DVT were 12.7 and 17.7, respectively.

Comparing the rates of diagnosis of PE at each decade of age with the rate for those aged 20 to 29 years, the rate ratio increased exponentially up to age 89 years (Figure 6B). In patients aged 70 to 79 years and 80 to 89 years, the rate ratios for PE diagnosis were 20.6 and 27.9, respectively.

TRENDS IN POPULATION GROWTH

Between 1990 and 2003, the elderly population in the United States increased by 5.4 million (an increase from 8.5% of the population to 9.4% of the population). By 2020 the elderly population is predicted to increase by an additional 9.4 million, to become 11.0% percent of the general population.

Although a striking upward trend in the rate of diagnosis of DVT was observed among elderly patients during the past decade, the rate of diagnosis of PE remained constant in that population. Upward trends in the rate of diagnosis for DVT were more prominent with each increasing decade of age from 1990 to 1999. In contrast, the rate of diagnosis for PE was generally constant and did not show consistent, substantive increases in that decade. The reason for this disparity is uncertain but may reflect early diagnosis and treatment of DVT.

Diagnostic approaches for DVT and PE have changed markedly over the past 2 decades, in temporal harmony with the evolving literature.27,29 Our findings in the elderly reflect the diagnostic changes in clinical practice. Over the past decade, Doppler ultrasonography has supplanted contrast venography as the preferred diagnostic approach for DVT, and lung scanning has sharply declined as Doppler ultrasonography became established as a diagnostic test. Pulmonary angiography use in the elderly increased over the past 2 decades. Recently, spiral-computed tomography has emerged as a popular (but yet to be proven) diagnostic test for PE. As this test became widely available in the late 1990s, it is unlikely that its use has been indirectly captured by our trend analysis.30,31 An effect in the late 1990s, however, cannot be excluded. Impedance plethysmography was not included among the diagnostic tests for DVT because our data show that only 1.4% of leg tests were obtained with this method. Even during its period of peak use, in 1987, only 3.5% of diagnostic tests for DVT were done with impedance plethysmography.

An abundance of literature documents that the risk of venous thromboembolism increases with age.2-5,32-43 Our 21-year analysis, which captures the findings for venous thromboembolism for hospitalized patients, strongly endorses this prior knowledge. The dramatic change in the risk for DVT or PE with increasing age documented by our analysis of the NHDS database is based on a national rather than regional database and includes a broad spectrum of hospitalized patients rather than specific populations (eg, populations undergoing general or orthopedic surgery). The exponential increase with age in the rate of diagnosis for DVT and PE in the elderly emphasizes the impact of aging on the epidemiology of venous thromboembolism. Our findings are consistent with those of regional surveys performed in the United States.2,3 The NHDS database provides a valid measure of the challenges facing the US health care system with respect to the risk of DVT and PE with aging.

Recommendations for prophylaxis in surgical patients are partially based on the age of the patient.44 Patients younger than 40 years are considered at low risk for venous thromboembolism for specific in-hospital surgical groups, but being older than 40 years is considered a more important risk factor.44 This has led to the general sense that age as a risk factor has a break point.
at 40 years. Our data provide further insight into the risk of venous thromboembolism in the younger in-hospital population. Indeed, patients aged 30 to 39 years have almost a 2-fold increase in the risk of DVT or PE compared with younger patients. The concept that the elderly are at the greatest need for thromboprophylaxis is emphasized by our data, which show a 18- to 28-fold increase in the risk for DVT or PE in patients 70 years or older compared with those aged 20 to 29 years.

In an effort to include all patients with DVT or PE, we used some codes that are nonspecific (451.8 phlebitis and thrombophlebitis of other sites and 451.9 phlebitis and thrombophlebitis of unspecified sites). Code 451.8 includes not only the iliac vein but also thrombophlebitis of the breast. However, thrombophlebitis of the breast constituted only 3% of all DVTs. Regarding codes 634.6, 635.6, 636.6, 637.6, and 638.6 (embolism during abortion), some women with nonthromboembolic embolism were included. However, among women aged 10 to 54 years who had PE, only 0.8% had embolism during abortion.

Several additional methodological issues require consideration. They concern the sensitivity and specificity45 of the NHDS summary sheet for capturing diagnostic test use, the “upcoding” of diagnoses and procedures that occurs over time (a phenomenon referred to as the Diagnosis-Related Group [DRG] “creep”),46 and changes over time (a phenomenon referred to as the Diagnosis-Related Group [DRG] “creep”),46 and changes over time to the ICD-9-CM coding system. In the early 1980s, the Health Care Financing Administration introduced DRGs as a mechanism for reimbursing hospitals providing care to Medicare recipients. Hospital administrators rapidly recognized that reimbursement was directly linked to the extent of coding for individual patients.47 The phenomenon of DRG creep is thus an artifact of coding that might have increased the sensitivity of coding when this method of reimbursement was introduced.48 The trends that we report do not appear to have been affected by DRG creep because, for middle-aged and younger patients, the trends for DVT and PE decreased or were static. As for the issue of changes over time to the ICD-9-CM coding system, there were no confounding changes to the coding scheme for PE, DVT, or associated procedures during the 21-year interval studied. Thus, it is unlikely that changes to ICD-9-CM perturb our findings. A minor issue, which concerns a minimal number of procedures, is the atypical use of a diagnostic procedure. Ventilation-perfusion lung scanning prior to tho-

Figure 5. Use of lung scans and pulmonary angiography by age group (1979-1999). A, Radioisotopic lung scan use was highest in elderly patients (≥70 years) (P<.001). B, The rate of use of pulmonary angiograms was higher in elderly patients (P<.001).

Figure 6. Rate ratios for the diagnosis of deep venous thrombosis (DVT) and pulmonary embolism (PE) were averaged over 21 years. A, The rate ratios for the diagnosis of DVT increased exponentially (95% confidence intervals were too narrow to display). B, The rate ratios for the diagnosis of PE increased exponentially (95% confidence intervals were too narrow to display).
racic surgery and pulmonary angiography for chronic pulmonary hypertension are 2 examples of atypical procedure use, and noninvasive or less invasive diagnostic tests performed in the outpatient setting may have resulted in an underestimate of the atypical use of these procedures. Outpatient treatment of DVT is unlikely to have affected the findings during the 21-year interval studied. It is recognized that hospital discharge data incompletely capture many diagnoses and procedures. We emphasize directional trends and relative differences, rather than absolute values, in the rates of diagnosis.

In conclusion, our findings support the literature and emphasize that a disproportionately high risk of thromboembolic disease occurs with age. Diagnostic approaches to DVT and PE in the elderly have changed markedly in temporal harmony with the evolving literature, and our findings on diagnostic trends capture this change.

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