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Original Article

The Incidence and Economic Burden of In-Hospital Venous Thromboembolism in the United States

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ABSTRACT

Background: Venous thromboembolism (VTE) is a potentially preventable and costly complication after total hip arthroplasty (THA) and total knee arthroplasty (TKA). The in-hospital incidence and economic burden of VTE following total joint arthroplasty (TJA) in the United States is unknown. The aim of this study was to examine this issue.

Methods: The Nationwide Inpatient Sample was used to estimate the total number of THA, TKA, and VTE events using International Classification of Diseases, Ninth Revision procedure codes from years 2002 to 2011. The rate of in-hospital deep vein thrombosis (DVT) and pulmonary embolism (PE), associated length of hospitalization, and current and projected in-hospital charges were obtained.

Results: Revision arthroplasties had higher rates of in-hospital VTE compared to primary TJAs (2.5% vs 1.6%, $P < .0001$). Among primary TJAs, the median rate of in-hospital VTE was 0.59% (0.55%-0.63%) for primary THA and 1.01% (0.94%-1.08%) for primary TKA. Revision THAs developed more VTE events compared to revision TKAs (1.35% [1.25%-1.46%] vs 1.16% [1.07%-1.26%]). Patients with a VTE have longer hospitalizations (median primary TKA: 7 vs 3; median primary THA: 6 vs 3, $P < .0001$). The overall rate of VTE decreased over the last decade; however, the PE rates have remained relatively constant. Moreover, the associated costs with VTE events have increased significantly over the last decade.

Conclusion: Based on the analysis of the Nationwide Inpatient Sample database, the rate of in-hospital DVT following TJA appears to have declined over the last decade while the incidence of PE has remained constant. This may indicate that the current recommendations by the American Academy of Orthopaedic Surgeons for VTE prophylaxis are adequate for preventing DVT without increasing the rate of PE or that institutional screening and reporting of DVT has been reduced because DVTs became a "never" event.

Pulmonary embolism (PE) and deep vein thrombosis (DVT), together referred to as venous thromboembolism (VTE), are serious and potentially preventable complications after total joint arthroplasty (TJA) that can be fatal [1,2]. Some of the associated risk factors for VTEs are obesity, total knee arthroplasty (TKA), increased comorbidities, chronic obstructive pulmonary disease, atrial fibrillation, anemia, depression, and hypercoagulable states [3,4]. Due to the potentially fatal sequelae following VTEs, prophylaxis is routinely administered in patients undergoing TJA.

Various preventive and treatment modalities are used for VTE. Various organizations, including the American Academy of Orthopedic Surgeons (AAOS) and the American College of Chest Physicians, have provided guidelines for preventing VTE following TJA [5,6]. These guidelines aim to provide the most evidence-based approach for prevention of VTE in TJA patients while preventing the potential, and in some circumstances more drastic, adverse events associated with the administration of VTE prophylaxis. It is true to state that guidelines from both organizations now recognize less aggressive modalities such as mechanical compression and aspirin as acceptable modalities of VTE prophylaxis.

In recent years, there have been numerous changes in the practice of orthopedic surgery with emphasis on early ambulation of patients and a national trend toward the use of hypotensive

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Table 1
Demographics.

Procedure	Number of Patients	Mean Age (95% CI)	Female (95% CI)
Primary THA	515,082	65.4 (65.2-65.6)	56.7 (56.5-56.9)
Revision THA	81,966	67.3 (67.1-67.6)	58.1 (57.7-58.6)
Primary TKA	1,073,823	66.5 (66.3-66.6)	63.6 (63.4-63.8)
Revision TKA	91,625	65.7 (65.5-65.9)	58.3 (57.8-68.7)

THA, total hip arthroplasty; TKA, total knee arthroplasty.

regional anesthesia, both of which have been demonstrated to result in a reduction in the incidence of VTE [7]. Numerous newer agents for VTE prophylaxis have also been introduced that include oral factor X inhibitors [8]. The question that remains is whether changes in our surgery and anesthesia, together with the shift in our approach for VTE prophylaxis, have led to any decline in the incidence of VTE in general, and PE in particular. This study, using the Nationwide Inpatient Sample (NIS) database between 2002 and 2011, was designed for the following: (1) determine the trends in the incidence of DVT and PE over the last decade; (2) determine the inpatient charges associated with the management of DVT and PE; and (3) propose a projection for 2030 for the potential costs associated with developing VTE in the US inpatient healthcare.

Materials and Methods

Study Design

NIS data from the Agency for Healthcare Research and Quality were used to establish a 10-year retrospective cohort of patients who underwent primary and revision TJA in the United States between January 1, 2002 and December 31, 2011 [9]. The NIS is the largest longitudinal, all-payer hospital database in the United States consisting annually of approximately 1000 hospitals and 7-8 million records, which represents approximately 20% of all hospital discharges in the United States. The NIS was explicitly designed by the Healthcare Cost and Utilization Project to assist in developing better healthcare policies. The database contains patient demographics along with comorbid conditions, hospital stay variables, diagnostic codes (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM]), hospitalization duration, discharge destination, and total in-hospital charges. Because all available information in the NIS database is deidentified, this study was exempted from requiring institutional review board approval.

Patient Selection

From the NIS database, a query was performed using ICD-9-CM codes to identify patients who underwent primary or revision total hip arthroplasty (THA) (81.51 and 81.53, and 00.70-00.73), as well as primary or revision total TKA (81.54-81.55 and 00.80-00.84).

A total of 1,762,496 TJAs were included for analysis including 515,082 primary THAs, 81,966 revision THAs, 1,073,823 primary TKAs, and 91,625 revision TKAs (Table 1).

Outcome Variables and Statistical Analysis

Using a query of the NIS database, the following variables were identified: PE and DVT events (ICD-9-CM codes: 451.1, 451.2, 451.8, 451.9, 453.2, 453.4, 453.8, 453.9, 415.11, and 415.19), hospital charges, and duration of hospital stay.

The number of THA and TKA and those that sustained VTE during the initial inpatient admission was extracted from the NIS database from 2002 to 2011. This was identified from the discharge diagnosis weighting patients using discharge weights. Using sample weight and clustering factors, the estimated national numbers were obtained with survey stratification from the NIS database. Trends in the VTE rate were calculated using a logistic regression analysis.

Table 2
Overall Median Incidence Between 2002 and 2011.

Procedure	Deep Venous Thrombosis (95% CI)	Pulmonary Embolism (95% CI)	Venous Thromboembolism (95% CI)
Primary THA	0.40 (0.37-0.43)	0.23 (0.21-0.25)	0.59 (0.55-0.63)
Revision THA	1.06 (0.97-1.16)	0.37 (0.33-0.42)	1.34 (1.25-1.46)
Primary TKA	0.62 (0.56-0.69)	0.46 (0.43-0.48)	1.01 (0.94-1.08)
Revision TKA	0.88 (0.80-0.97)	0.34 (0.30-0.38)	1.16 (1.07-1.26)

THA, total hip arthroplasty; TKA, total knee arthroplasty.

The NIS survey includes the total charges for each discharge. The Healthcare Cost and Utilization Project created a set of companion files starting from 2001 entitled the inflation adjusted total charges. The charges were adjusted to 2011 dollars using the Consumer Price Index inflation calculator [10]. The 95% confidence interval (CI) for the rate was based on the standard error of the parameter estimates.

Statistical analysis was performed using R 3.1 (R Foundation for Statistical Computing, Vienna, Austria). The “survey” package for R was used to derive estimates of means, medians, standard deviations, standard errors, rates, and CIs based on the discharge-level weighting of the NIS and inflation adjusted total charges. A logistic regression analysis was used to evaluate trends in the VTE rate.

Results

Overall, the median incidence of in-hospital VTE events during the initial hospitalization was 0.59% (0.55%-0.63%) and 1.01% (0.94%-1.08%) for primary THAs and TKAs, respectively (Table 2). The total number of VTE events decreased for primary THA by 7.1% (95% CI −5.9 to −8.2) and reduced for primary TKA by 5.2% (95% CI −4.5 to −5.8) annually. The decline pattern was comparable for revision TKA ($P = .08$), with VTE events decreasing by 1.8% (95% CI −3.9 to 0.3) per year. VTE events had a fluctuating pattern in revision THAs; although the overall rate decreased, it was not statistically significant ($P = .16$). In revision THAs, the logistic model demonstrated an annual decrease of 1.4% (95% CI −3.4 to 0.6). Interestingly, while the DVT rate declined, PEs remained relatively constant throughout the study period for both primary THAs and TKAs (Fig. 1).

Patients had longer hospitalization when they experienced postoperative VTEs compared to those without VTE ($P < .0001$): 7 vs 3 days for primary THA; 6 vs 3 days for primary TKA; 9 vs 4 days for revision THA; and 7 vs 3 days for revision TKA.

VTE events were associated with a significant increase in in-hospital charges. The median charge for a primary TKA was $38,791 (37,387-39,936) and increased to $53,307 (51,392-55,470) when complicated by VTE, that is, a $14,516 net increase in charges ($P < .0001$). In revision TKA, median charges increased by $29,443 from $48,667 (95% CI 46,988-50,462) to $78,110 (95% CI 74,285-84,481) ($P < .0001$). The median charges for primary THA increased from $41,605 (95% CI 40,374-42,883) to $62,263 (60,319-65,022) (difference $20,657, $P < .0001$); and in revision THA, the median cost increased from $50,165 (95% CI 48,438-51,984) to $78,065 (95% CI 74,111-84,481) (difference $29,443, $P < .0001$).

The costs associated with VTE events have risen significantly within the last decade. In 2002, a VTE event was associated with $13,076 (95% CI 11,829-14,330) additional charges for a primary TKA,