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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.

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.

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.

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,

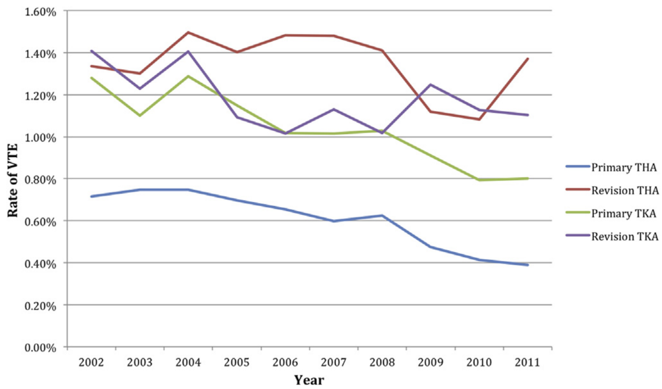

Fig. 1. The incidence of in-hospital VTE after THA and TKA in the United States (2002-2011). THA, total hip arthroplasty; TKA, total knee arthroplasty; VTE, venous thromboembolism.

whereas this amount increased up to $18,184 (95% CI 15,668-20,700) in 2011. The associated charges increased from $15,033 (95% CI 13,547-16,518) to $26,355 (95% CI 23,404-29,405) and from $24,103 (95% CI 22,063-25,032) to $40,278 (95% CI 36,037-44,519) for primary THA and revision TKA, respectively, in the same time span. Hospital charges increased by $52,534 (95% CI 47,965-57,103) when VTE events occurred in a revision THA in 2011, compared to $27,036 (95% CI 24,851-29,221) for revision THA in 2002 (Table 3).

Discussion

Harm associated with therapeutic or diagnostic interventions frequently complicates major surgeries [11]. VTE is a serious and potentially preventable complication after TJA, which has been a major concern for the orthopedic community. Reports have shown that the venographic rates of VTE after TKA and THA can be as high as 60% without proper prophylaxis [1]. During the last decade, several clinical practice guidelines for VTE prophylaxis have been published that frequently differed in their recommendations.

Overall, our results demonstrate that the incidence of DVT and PE is uncoupled; DVTs have decreased while the incidence of PEs has remained relatively stable throughout the last decade. We believe that the reduction in DVT rates may largely be attributed to recent guidelines, which are primarily focused on symptomatic VTEs. Because the recent literature strongly discourages the use of routine duplex scans or venography after TJA, patients who were

Table 3
Historical In-Hospital Charges of TJA With and Without VTE in the United States (2002-2011).

Year	No VTE (95% CI)	VTE (95% CI)	Net Difference (95% CI)
Primary THA			
2002	$33,296.90 (31,970.22-34,919.92)	$48,329.55 (44,713.75-56,052.68)	$15,032.65 (11,416.85-24,082.45)
2003	$36,377.93 (34,693.46-38,278.28)	$49,816.77 (45,366.05-54,312.62)	$13,438.84 (8988.12-19,619.15)
2004	$38,669.12 (36,701.73-40,866.46)	$55,847.13 (51,817.43-61,400.53)	$17,178.02 (13,148.31-24,698.79)
2005	$39,708.31 (38,035.39-41,544.20)	$59,759.51 (52,205.70-66,520.67)	$20,051.21 (12,497.40-28,485.28)
2006	$40,199.95 (38,578.78-42,054.50)	$57,855.79 (53,742.61-64,472.54)	$17,655.84 (13,542.66-25,893.76)
2007	$42,816.66 (40,667.47-45,126.41)	$68,063.00 (61,960.14-75,146.57)	$25,246.34 (19,143.47-34,479.09)
2008	$44,816.70 (42,716.64-47,013.91)	$65,901.14 (60,115.21-70,786.96)	$21,084.45 (15,298.51-28,070.31)
2009	$43,616.86 (40,879.32-46,504.92)	$69,053.93 (64,456.81-74,628.15)	$25,437.07 (20,839.95-33,748.82)
2010	$46,357.01 (42,962.01-49,988.25)	$80,716.81 (73,775.75-88,208.48)	$34,359.80 (27,418.74-45,246.47)
2011	$48,312.00 (45,393.00-51,294.00)	$74,666.70 (68,838.62-81,819.98)	$26,354.70 (20,526.62-36,426.98)
Revision THA			
2002	$38,536.33 (36,617.21-40,825.39)	$65,572.03 (58,325.65-80,292.26)	$27,035.70 (19,789.32-43,675.05)
2003	$42,668.22 (39,548.52-45,822.40)	$86,604.00 (67,669.00-106,056.39)	$43,935.79 (25,000.79-66,507.87)
2004	$45,070.05 (42,710.42-47,682.11)	$78,758.55 (70,325.75-91,820.94)	$33,688.50 (25,255.70-49,110.52)
2005	$45,034.28 (42,662.85-47,253.78)	$80,165.57 (72,995.70-96,919.37)	$35,131.29 (27,961.42-54,256.51)
2006	$48,264.76 (45,644.12-50,714.88)	$88,210.66 (73,936.80-106,551.07)	$39,945.90 (25,672.04-60,906.94)
2007	$52,771.76 (49,709.03-56,007.06)	$93,656.27 (82,160.22-112,382.30)	$40,884.51 (29,388.47-62,673.27)
2008	$54,759.39 (51,220.28-57,890.48)	$113,155.70 (93,785.20-134,399.97)	$58,396.31 (39,025.81-83,179.68)
2009	$54,728.86 (50,889.97-58,838.26)	$101,665.62 (83,709.77-118,405.74)	$46,936.75 (28,980.91-67,515.76)
2010	$57,780.28 (53,681.49-62,433.46)	$97,188.06 (82,763.77-114,941.12)	$39,407.78 (24,983.50-61,259.63)
2011	$62,462.33 (58,102.30-67,186.44)	$114,996.42 (102,994.45-132,058.54)	$52,534.08 (40,532.12-73,956.23)
Primary TKA			
2002	$30,797.35 (29,591.96-32,065.25)	$43,877.00 (35,803.35-52,306.86)	$13,079.65 (5006.00-22,714.89)
2003	$32,508.72 (31,095.73-34,039.29)	$46,319.36 (42,545.11-50,772.39)	$13,810.64 (10,036.39-19,676.65)
2004	$35,005.06 (33,539.07-36,605.19)	$49,154.42 (43,567.71-54,918.71)	$14,149.36 (8562.65-21,379.63)
2005	$36,312.80 (34,874.35-37,836.63)	$50,778.05 (47,362.98-55,402.90)	$14,465.25 (11,050.18-20,528.54)
2006	$38,076.68 (36,587.08-39,639.91)	$51,434.06 (48,478.08-54,978.59)	$13,357.38 (10,401.41-18,391.51)
2007	$39,134.51 (37,149.79-41,319.50)	$53,111.24 (50,038.01-56,032.22)	$13,976.73 (10,903.49-18,882.43)
2008	$40,499.58 (38,540.58-42,604.85)	$54,921.54 (50,861.79-58,696.50)	$14,421.96 (10,362.20-20,155.92)
2009	$41,601.33 (39,491.75-43,997.15)	$58,673.01 (54,765.84-62,915.70)	$17,071.68 (13,164.51-23,423.95)
2010	$43,364.34 (41,021.57-45,938.36)	$62,901.76 (58,535.46-68,551.51)	$19,537.42 (15,171.12-27,529.94)
2011	$45,182.70 (42,798.00-47,823.00)	$63,366.77 (59,256.25-68,373.24)	$18,184.07 (14,073.55-25,575.24)
Revision TKA			
2002	$35,665.98 (33,919.70-37,425.17)	$59,769.09 (49,705.63-70,192.12)	$24,103.12 (14,039.65-36,272.41)
2003	$38,960.02 (36,439.39-41,396.38)	$66,168.37 (59,908.37-75,783.56)	$27,208.36 (20,948.36-39,344.17)
2004	$42,016.01 (39,610.68-44,486.63)	$64,563.77 (53,077.27-74,786.74)	$22,547.76 (11,061.26-35,176.05)
2005	$43,194.44 (40,577.61-45,946.03)	$69,727.35 (62,144.68-80,439.67)	$26,532.91 (18,950.24-39,862.05)
2006	$45,827.12 (43,534.01-48,294.63)	$73,077.77 (57,002.24-85,231.73)	$27,250.65 (11,175.12-41,697.72)
2007	$48,812.96 (45,895.14-52,063.27)	$74,913.01 (62,768.18-96,139.56)	$26,100.05 (13,955.21-50,244.42)
2008	$53,523.52 (50,128.43-57,175.15)	$84,121.59 (76,636.86-92,021.62)	$30,598.07 (23,113.34-41,893.19)
2009	$53,655.49 (49,658.05-57,334.56)	$92,374.49 (80,426.90-100,212.61)	$38,719.00 (26,771.41-50,554.55)
2010	$56,511.76 (52,599.53-60,554.28)	$101,637.90 (85,967.03-117,283.36)	$45,126.13 (29,455.27-64,683.82)
2011	$62,308.10 (58,496.26-66,844.03)	$102,586.15 (84,688.19-125,372.04)	$40,278.05 (22,380.09-66,875.77)

THA, total hip arthroplasty; TJA, total joint arthroplasty; TKA, total knee arthroplasty; VTE, venous thromboembolism.

previously overdiagnosed with asymptomatic VTEs likely went undetected [12,13]. While we may be underdiagnosing DVTs, the stable PE rate is reassuring because it suggests that the untreated asymptomatic DVTs are not resulting in an increase in potentially fatal PEs. Jacobs et al [5] in their prospective analysis of 3289 consecutive TJAs evaluated the first-generation AAOS clinical guidelines of VTE prophylaxis and concluded that the proper use of the guidelines could minimize adverse complications, that is, VTE events.

The decreasing rates of DVTs may also be a reflection of recent changes in practice for VTE chemoprophylaxis. In addition to focusing on symptomatic VTE as an endpoint, the current AAOS guidelines support risk stratification strategies and have no recommendations for a specific chemoprophylaxis agent [14]. This flexibility allows surgeons to balance efficacy with bleeding complications. However, the decreasing rates of DVT may result from underreporting of this because the Center for Medicare and Services made VTE a “never” event and started financially penalizing institutions in 2009.

Additional associated hospital charges of VTEs have increased significantly during the last decade. This could be attributed to the increase in hospitalization charges over the study period, annual economical inflation, and increased length of stay for patients with VTE. Furthermore, several studies have demonstrated that aggressive chemical prophylaxes with potent modalities are associated with numerous complications, such as wound-related problems, infection, and increased hematoma formation, all of which could potentially increase the length of hospitalization, and may require further procedures that could lead to an increase in hospital charges [15-17].

The NIS database and this study have certain limitations, and our findings should be interpreted in light of these shortcomings. As an inherent limitation of using national administrative claims data, the study has inadequate clinical data related to VTE, including the type of prophylaxis. We only investigated in-hospital VTE events during initial hospitalization, which represents a proportion of the total VTEs that may occur after THA and TKA over a longer postoperative period [18-20]. We were also unable to evaluate the type of prophylactic modalities and the anticoagulant protocols that were applied for the management of VTE events. The other limitation was that the estimated hospital charges in our study did not include the additional costs of the surgical service provided by the orthopedic surgeons or services from other physicians, such as internists and anesthesiologists. Although physical therapy, rehabilitation, home care, and pharmaceutical treatments play an important role, we were unable to investigate charges related to these services. Therefore, the presented charges and the economical impact presented in this study are underestimated and the actual impact could be higher. Notwithstanding of all these limitations, our study reflects population-based estimates of in-hospital VTE incidence and charges related to contemporary standards of care in the United States over a decade, using an ample sample size that can compensate for limitations.

In conclusion, the in-hospital incidence of DVT events after THA and TKA is decreasing while PE events have remained relatively stable. Nevertheless, it appears that the associated hospital charges increased significantly, imposing a huge burden on the healthcare system. Thus, the current recommendations by the AAOS for VTE prophylaxis are adequate for preventing DVT after primary and revision TJA, without increasing the rate of PE or that reporting of these events is declining. Further work should be conducted to reduce the cost of VTE events, while also decreasing the rate of PEs.

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