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Timing of complications following surgery for geriatric hip fractures

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ABSTRACT

Introduction: Despite abundant literature present on complications following hip fracture surgery, few studies have focused on the timing of these complications.

Materials and methods: The 2015–2016 American College of Surgeons – National Surgical Quality Improvement Program database was queried for patients ≥65 years of age undergoing hip fracture surgery, due to trauma, using CPT-Codes for total hip arthroplasty (27130), Hemiarthroplasty (27125) and Open Reduction/Internal Fixation (ORIF) (27236, 27244, 27245). For each complication being studied, the median time to diagnosis was determined along with the interquartile range (IQR). Cox-regression analyses were used to assess complication timings between various surgeries.

Results: A total of 31,738 were included in the final cohort. The median time of occurrence (days) for myocardial infarction was 2 [IQR 1–6], pneumonia 4 [IQR 2–12], stroke/CVA 3 [IQR 1–10], pulmonary embolism 5 [IQR 2–14], urinary tract infection (UTI) 8 [IQR 2–15], deep venous thrombosis (DVT) 9 [IQR 4–17], sepsis 11 [IQR 5–19], death 12 [IQR 6–20], superficial surgical site infection (SSI) 16 [IQR 12–22], deep SSI 23 [IQR 15–24] and organ/space SSI 19 [IQR 15–23]. Undergoing a THA vs. ORIF for hip fracture was associated a relatively early occurrence of pneumonia (day 3 [IQR 1–5.25]; $p = 0.029$) and urinary tract infection (day 4 [IQR 1–13]; $p = 0.035$) and a later occurrence of organ/space SSI (day 23.5 [IQR 19.5 –26.75]; $p = 0.002$).

Conclusion: Orthopaedic trauma surgeons can utilize this data to optimize care strategies during the time-periods of highest risk to prevent complications from occurring early on in the course of post-operative care.

1. Introduction

Hip fractures are one of the most common clinical cases encountered by orthopaedic surgeons. With an increase in the life-expectancy of individuals worldwide,[1] the expected proportion of patients presenting with a hip fracture secondary to a fall is expected to rise. The worldwide incidence of hip fractures is projected to reach around 21 million cases, with an associated $446 billion in costs associated with management.[2–4] Though surgery for hip fractures impacts lifetime societal cost-savings by a direct improvement in the quality of life,[5] the relatively high morbidity[4,6] and mortality rates,[7–11] remain important concerns and emphasizes the need for continued improvement in patient care. Though past studies have focused on identification of the rates of complications and the various risk factors associated with each adverse event, few studies have focused on identifying the timing of complications in these patients.

As we move towards the era of bundled-payment models,[12] which aim at improving the quality of care while minimizing costs, analyzing the timing of complications may allow providers to accurately identify post-operative time periods that may require more closer surveillance and perhaps, better optimization of care strategies. The current study utilized a large national multi-center surgical database to answer the primary research questions – 1) What is the timing of the common complications that occur after hip fracture surgery in geriatric patients? 2) Does the type of procedure for treatment of hip fracture impact the timing of when complications may occur post-operatively? and 3) Whether occurrence of a complication is significantly associated with sustaining other complications?

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2. Materials and methods

2.1. Database

This was a retrospective cohort study performed using the American College of Surgeons (ACS)-National Surgical Quality Improvement Program (NSQIP) database. The ACS-NSQIP collects surgical information from more than 500 hospitals across the United States.[13] Data are recorded for more than 150 preoperative, intra-operative and post-operative variables up to 30-days following operations. The data are collated by trained surgical and clinical reviewers with audit reports showing an inter-reviewer disagreement rate below 2%.[13]

The 2015–2016 ACS-NSQIP databases were queried for patients undergoing hip fracture repair using CPT codes for open reduction/internal fixation (ORIF) (CPT-27236, CPT-27244, CPT-27245), hemiarthroplasty (HA) (CPT-27125) and total hip arthroplasty (THA) (CPT-27130). The data were filtered to remove surgeries being done for malignancies, deformities and degenerative conditions such as osteoarthritis. This was done to ensure that only procedures being performed for fractures were included in the study. Furthermore, only patients ≥65 years of age were included to accurately capture a geriatric-relevant population for our study. Records with missing data were excluded from our study. A total of 31,738 patients were included in the final cohort for analysis.

2.2. Baseline demographics & complications

Patient characteristics that were extracted from the database included age (categorized into 65–79 years, 80–89 years and ≥90 years), gender (male and female), Body Mass Index (BMI), procedure type (THA, HA and ORIF) and co-morbidities as recorded by NSQIP. A total of 11 complications were investigated in this study – Superficial Surgical Site Infection (SSI), Deep SSI, Organ/Space SSI, Pneumonia, Pulmonary Embolism, Deep Venous Thrombosis (DVT), Urinary Tract Infection (UTI), Stroke/CVA, Myocardial Infarction (MI), Sepsis and Death within 30 days of surgery. The median length of post-operative stay was used to characterize complications into early (≤4 days) vs. late (>4 days).

2.3. Statistical analysis

Individual rates of complications were reported using descriptive analysis. In order to assess the timing of complications, the median day of diagnosis along with the interquartile range (IQR) was calculated for each complication. Relative percentages of each complication that occurred prior to discharge were also calculated. Pearson Chi-Square test was used to analyze the presence of significant associations in between complications by the construction of a co-variance matrix. Furthermore, to assess differences in the timing of complications between the three procedure types (THA, HA and ORIF), individual Cox-regression survival models were created for each complication while adjusting for other baseline clinical characteristic (age, gender, BMI and co-morbids).

All statistical analysis was carried out using SPSSv23 (IBM Corp, Armonk, NY). For all statistical purposes, a p-value of less than 0.05 was considered significant.

Table 1
Baseline Clinical Characteristics of the study population.

Variable	Number	Percentage
Total	31,738	100%
Age(years)		
65–79	10,427	32.9%
80–89	14,002	44.1%
≥90	7309	23.0%
Gender		
Male	9211	29.0%
Female	22,527	71.0%
Body Mass Index (BMI; kg/m^2)		
<25.0	18,145	57.2%
25.0–29.9	9000	28.4%
30.0–34.9	3263	10.3%
≥35.0	1330	4.2%
Procedure Type		
Total Hip Arthroplasty (THA)	1559	4.9%
Hemiarthroplasty (HA)	4596	14.5%
Open Reduction/Internal Fixation (ORIF)	25,583	80.6%
Co-Morbids		
Insulin-Dependent Diabetes Mellitus (IDDM)	2349	7.4%
Non-Insulin Dependent Diabetes Mellitus (NIDDM)	3337	10.5%
Smoking	2945	9.3%
Dyspnea at Rest	350	1.1%
Dyspnea at Moderate Exertion	1989	6.3%
Functional Health Status prior to surgery		
Independent	24,700	77.8%
Partially Dependent	5726	18.0%
Totally Dependent	1033	3.3%
Unknown	279	0.9%
Pre-operative Ventilator Use	55	0.2%
History of severe COPD	3612	11.4%
History of Congestive Heart Failure (CHF)	1239	3.9%
Hypertension requiring medication	22,147	69.8%
Chronic Steroid Use	1590	5.0%
>10% body-weight loss in last 6 months	491	1.5%
Bleeding Disorders	5406	17.0%
Transfusion≥1 units of packed RBCs in 72 h before surgery	1398	4.4%
Disseminated Cancer	479	1.5%

Table 2
Frequencies and median day of diagnosis of post-operative complications.

Complication	Number	Percentage	Median day [Interquartile range]
Superficial SSI	177	0.56%	16 [12–22]
Deep SSI	75	0.24%	23 [15–24]
Organ/Space SSI	73	0.23%	19 [15–23]
Pneumonia	1344	4.23%	4 [2–12]
Pulmonary Embolism	230	0.72%	5 [2–14]
Deep Venous Thrombosis (DVT)	358	1.13%	9 [4–17]
Urinary Tract Infection (UTI)	1418	4.47%	8 [2–15]
Stroke/CVA	248	0.78%	3 [1–10]
Myocardial Infarction	578	1.82%	2 [1–6]
Sepsis	356	1.12%	11 [5–19]
Death	1781	5.61%	12 [6–20]

3. Results

A total of 31,738 patients met inclusion/exclusion criteria and were included in the study. Baseline demographics of the study population are shown in Table 1. The majority of the patients were female (N = 22,527; 71.0%) and were in the age group of 80–89 years (N = 14,002; 44.1%). The most common type of procedure performed in the study population was ORIF (N = 25,583; 80.6%) followed by HA (N = 4596; 14.5%) and THA (N = 1559; 4.9%). The median length of stay was 4.0 days.

Individual complication rates are shown in Table 2. The most common complication was death (5.61%) followed by UTI (4.47%) and pneumonia (4.23%). Median day of diagnosis along with interquartile ranges are also shown in Table 2. The median time of diagnosis in days, in ascending order, for myocardial infarction was 2 [IQR 1–6], pneumonia 4 [IQR 2–12], stroke/CVA 3 [IQR 1–10], pulmonary embolism 5 [IQR 2–14], urinary tract infection (UTI) 8 [IQR 2–15], deep venous thrombosis (DVT) 9 [IQR 4–17], sepsis 11 [IQR 5–19], death 12 [IQR 6–20], superficial surgical site infection (SSI) 16 [IQR 12–22], deep SSI 23 [IQR 15–24] and organ/space SSI 19 [IQR 15–23]. Comparison of the timings of complications with those of arthroplasty[14] and spinal fusion[15] using past literature is shown in Fig. 1.

With the exception of surgical site infections, sepsis and death –the majority of complications were diagnosed <15 days following the surgery. Only MI, Stroke and pneumonia were defined as "early" complications. Furthermore, when characterized by timing relevant to discharge, the three most common post-operative complications that were diagnosed prior to discharge were myocardial infarction (76.1% of total occurrences of MI), pneumonia (67.3% of total occurrences of pneumonia) and stroke (69.4% of total occurrences of stroke), while surgical site infections (superficial, deep and organ/space) were primarily diagnosed following discharge (Table 3).

Individual co-variance matrices showed that all complications were significantly associated with the occurrence of at least one other complication, with the occurrence of pneumonia to be associated with a total of 7 other complications.

Individual cox-regression survival models showed that, following adjustment for baseline clinical characteristics, undergoing a THA for hip fracture repair was associated a relatively early occurrence of pneumonia (median day 3 [IQR 1–5.25]; p = 0.029) and urinary tract infection (median day 4 [IQR 1–13]; p = 0.035) and a later occurrence of organ/space SSI (Median day 23.5 [IQR 19.5–26.75]; p = 0.002) as compared to undergoing an ORIF (Fig. 2: A-K).

4. Discussion

The current study, using a cohort of more than 31,000 patients from a national surgical database, characterizes the timing of common complications following hip fracture repair in geriatric patients. Overall, our results indicate that the majority of the complications occurred within two weeks of the index procedure thus suggesting that careful follow-up and care of the patient can be used to effectively reduce the incidence of these adverse events in this period of "vulnerability."

Contrary to other complications, SSIs (superficial, deep and organ/space) occurred relatively later in the post-operative course. We also noted that the curves for superficial, deep and organ/space SSI did not plateau up to 30-day period thus pointing towards the fact that surgical site infections may potentially be occurring even after the 30-day period. These findings are similar to previous complication timing literature on arthroplasty[14] and spine,[15,16] and highlight the importance of careful and regular follow-up of patients even after the post-operative 30-day period to prevent the occurrence of this adverse event.

Our median days of diagnosis for several complications when compared to a recent study published by Bohl et al. investigating the timing of complications following total joint arthroplasty[14] were – MI: 3 vs. 2 days, Stroke: 2 vs. 3 days; pneumonia 4 vs. 4 days; pulmonary embolism: 3 vs 5 days, DVT: 6 vs. 9 days, UTI: 8 vs 8 days and sepsis 10 vs. 11. Though largely the median days were similar, differences in the timing of pulmonary embolism and DVT was seen. A plausible reason for this could be due to the use of pneumatic tourniquets in total joint arthroplasty,[14] which by their very principle of causing venous compression can predispose patients to developing thrombosis. Another reason for the findings could be due to differences in thrombo-prophylaxis protocols within the two groups. Given the emergent nature of hip fracture, as well as the hyper-coaguability induced by inflammation from trauma itself, surgeons may tend to employ an extended use of anti-thrombotic agents that may yield a protective effect with regard to the timings.

Using a co-variance matrix, we were able to elucidate from the data that all complications were associated with at least one other complication. This is particularly important as a multi-pronged approach would be required to prevent occurrence of these complications rather than just focusing on one adverse event. However, it is imperative to note that the co-variance matrix is only able to assess associations in between complications and does not establish causality between two different adverse events. Further study would be required to assess causal relationships between different adverse events following hip fractures.

Results from Cox-regressional models, showed that the timing of certain complications (UTI, pneumonia and organ/space SSI) varied between THA and ORIF. In essence, UTI and pneumonia typically occurred earlier following a THA. A possible reason for this difference could be due to the difference in catheterization practices for each procedure type which may impact the occurrences of

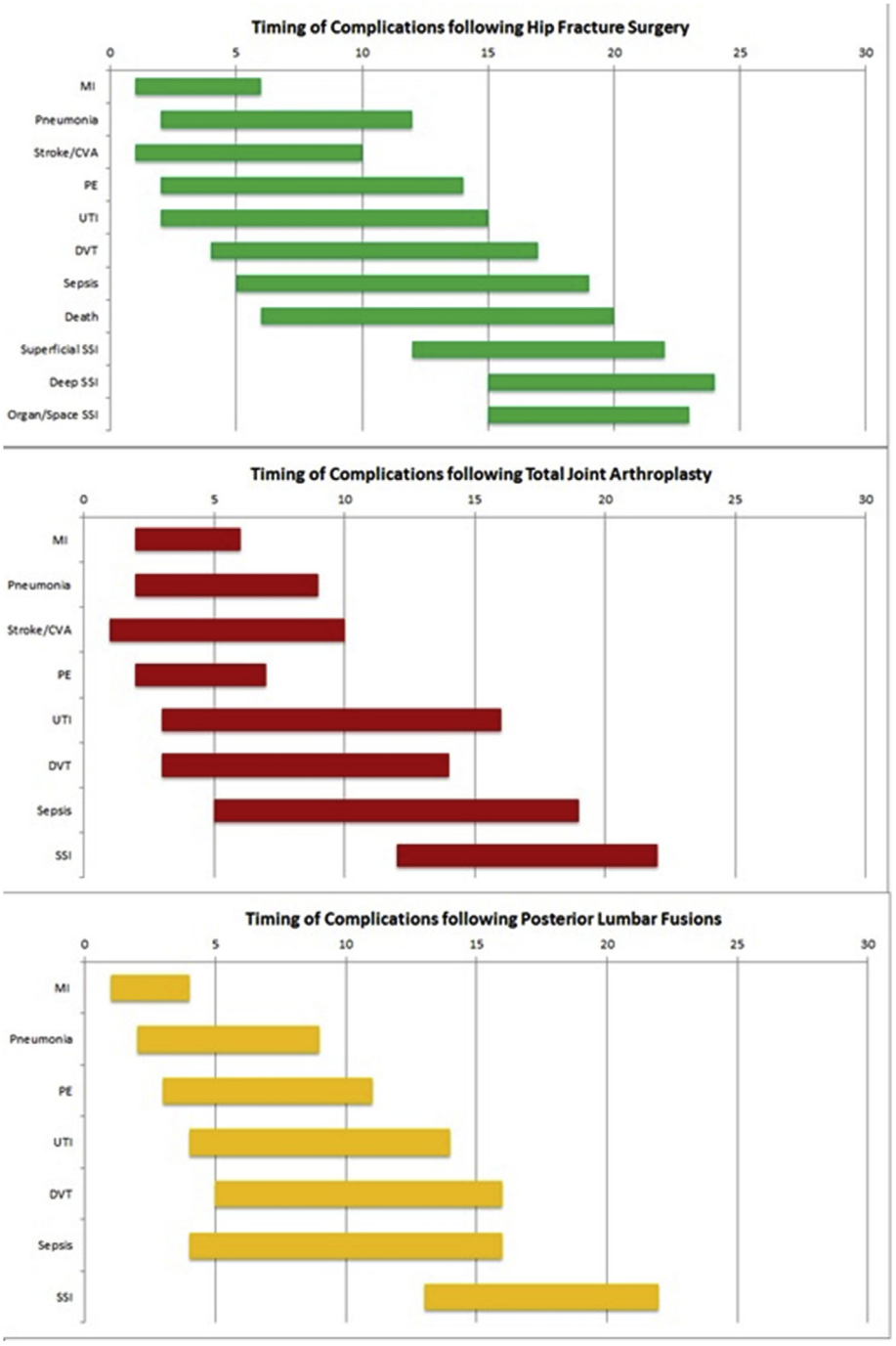

Fig. 1. Timing of complications of hip fractures relative to total joint arthroplasty[14] and posterior spinal fusions.[15]

Table 3
Frequencies of complications occurring prior to discharge.

Complications	Number prior to discharge	Percentage of total
Superficial SSI	29	16.4%
Deep SSI	6	8%
Organ/Space SSI	9	12.3%
Pneumonia	905	67.3%
Pulmonary Embolism	129	56.1%
Deep Venous Thrombosis (DVT)	162	45.2%
Urinary Tract Infection (UTI)	748	52.8%
Stroke/CVA	172	69.4%
Myocardial Infarction	440	76.1%
Sepsis	133	37.4%
Death	647	36.3%

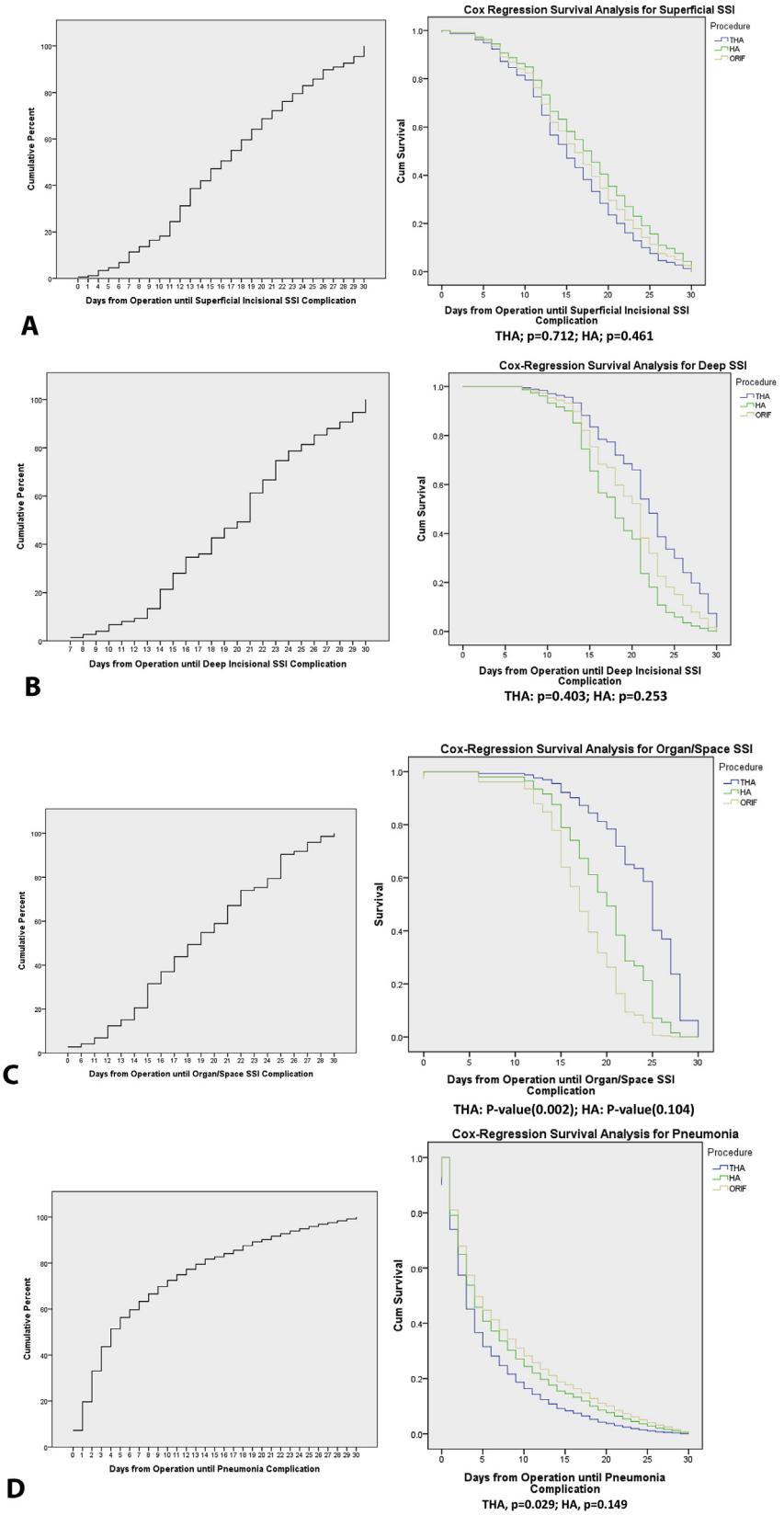

Fig. 2. (A-K) Figures showing distribution of complications over 30-day post-operative period (left) and Cox-regression survival analysis (Right) between different procedure types (THA, HA and ORIF) for each post-operative complication. P-values for differences in survival rates of complication, following adjustment for baseline clinical characteristics in Cox-regression, between various procedures are given below. ORIF was taken as the reference group while conducting comparisons. A, superficial SSI; B, deep SSI; C, organ/space SSI; D, pneumonia; E, pulmonary embolism; F, urinary tract infection; G, stroke/CVA; H, myocardial infarction; I, sepsis; J, deep vein thrombosis; and K, death.

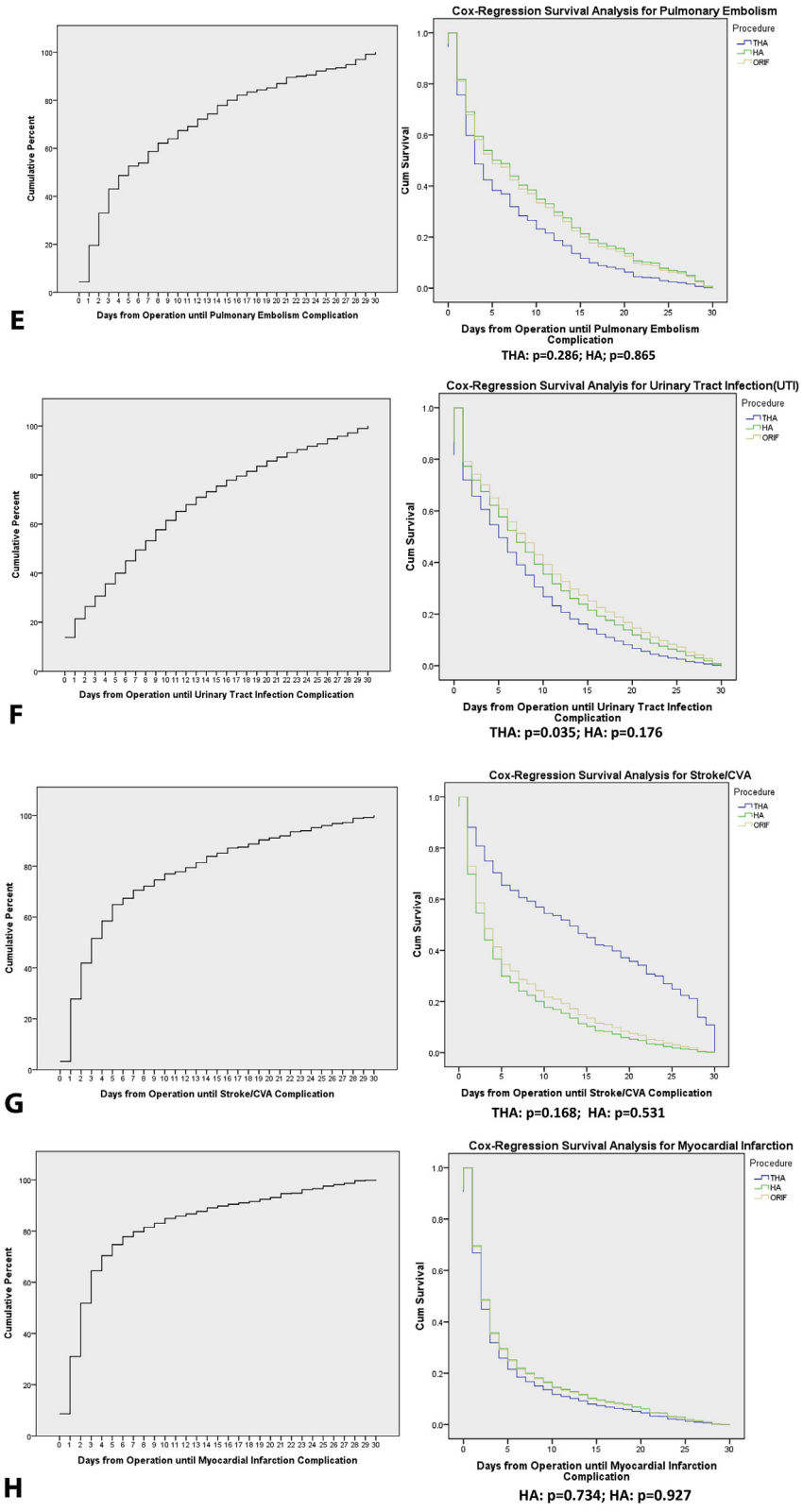

Fig. 2. (*continued*).

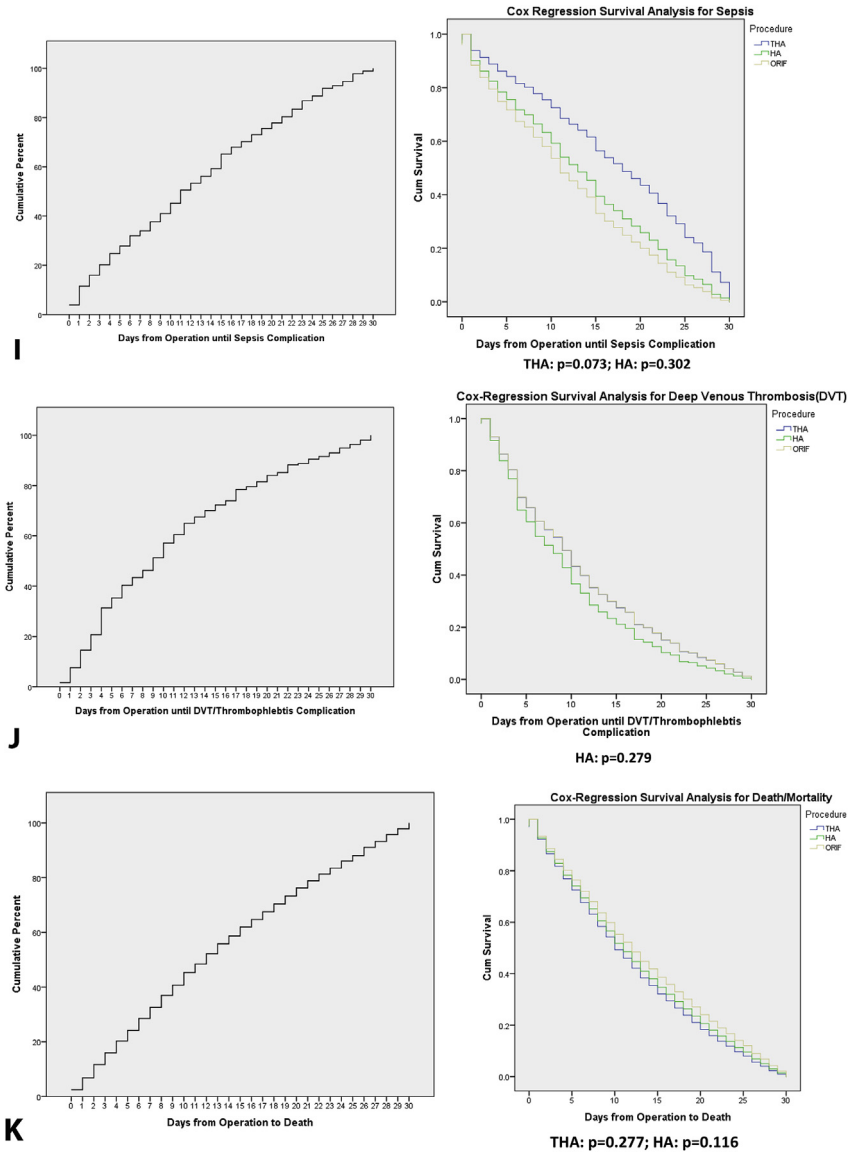

Fig. 2. (*continued*).

UTI. Future research needs to explore differences in catheterization practices between these procedures to come to a more affirmative conclusion. Another explanation for the findings could be that, following a THA, surgeons may have a lower threshold of obtaining urine analysis/culture if patients spike a temperature because of fear of hematogenous spread of an infection to the joint implant. However, currently the NSQIP does not hold enough surgical data to elucidate why there is a difference in the timings of these complications. Future studies need to focus on extracting more "granular" clinical data in order to reach this conclusion. Regardless, these results suggest an increased cautionary surveillance in the earlier post-operative period following a THA. Adoption of uniform, specific catheter protocols can be an effective way in reducing in the incidence of this common complication.[17,18]

The results of this study indicate that careful scheduling of follow-up visits focused on medical optimization, not just regular fracture follow-up, may help reduce complications. Adoption of low-thresholds for testing during these time periods by orthopaedic trauma surgeons can be an effective way in reducing the risk of complications. The findings of this study also promote the use and making of surgical registries with a longer-follow up to accurately capture complications when presenting research.

The study is not without limitations. First, the ACS-NSQIP records data only up to 30 days following the procedure. As mentioned before, this can be particularly limiting given that certain "late" complications such as SSI may be occurring well-beyond the specified period. Second, the NSQIP only captures data for a few complications as compared to other administrative databases. Third, the NSQIP does not provide data on post-operative venous thromboembolism prophylaxis which may affect complications such as DVT/PE. Finally, the majority of the hospitals participating in the NSQIP are large academic medical centers and therefore the results may not be truly representative of a national population.

Using a large cohort of patients from a national surgical database, we have characterized timing of the most common complications following hip fracture repair in geriatric patients. Orthopaedic trauma surgeons should utilize this data to promote heightened clinical awareness and low thresholds of testing during periods of highest risk to prevent occurrence of potentially

devastating adverse events.

Conflicts of interest

The authors received no funding for this study and report no conflict of interest.

Conflict of interest and source of funding

No conflicts of interest were declared by the authors. No funding was required for this study.

Disclosures

The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

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References

1. Inneh IA, Clair AJ, Slover JD, Iorio R. Disparities in discharge destination after lower extremity joint arthroplasty: analysis of 7924 patients in an urban setting. *J Arthroplasty*. 2016;31(12):2700–2704.
2. Cooper C, Campion G, Melton 3rd LJ. Hip fractures in the elderly: a world-wide projection. *Osteoporos Int*. 1992;2(6):285–289.
3. Johnell O. The socioeconomic burden of fractures: today and in the 21st century. *Am J Med*. 1997;103(2A):20S–25S. discussion 25S-26S.
4. Sathiyakumar V, Greenberg SE, Molina CS, Thakore RV, Obremskey WT, Sethi MK. Hip fractures are risky business: an analysis of the NSQIP data. *Injury*. 2015;46(4):703–708.
5. Gu Q, Koenig L, Mather 3rd RC, Tongue J. Surgery for hip fracture yields societal benefits that exceed the direct medical costs. *Clin Orthop Relat Res*. 2014;472(11):3536–3546.
6. Braithwaite RS, Col NF, Wong JB. Estimating hip fracture morbidity, mortality and costs. *J Am Geriatr Soc*. 2003;51(3):364–370.
7. Brauer CA, Coca-Perraillon M, Cutler DM, Rosen AB. Incidence and mortality of hip fractures in the United States. *J Am Med Assoc*. 2009;302(14):1573–1579.
8. Davidson CW, Merrilees MJ, Wilkinson TJ, McKie JS, Gilchrist NL. Hip fracture mortality and morbidity–can we do better? *N Z Med J*. 2001;114(1136):329–332.
9. Haentjens P, Magaziner J, Colon-Emeric CS, et al. Meta-analysis: excess mortality after hip fracture among older women and men. *Ann Intern Med*. 2010;152(6):380–390.
10. Schnell S, Friedman SM, Mendelson DA, Bingham KW, Kates SL. The 1-year mortality of patients treated in a hip fracture program for elders. *Geriatr Orthop Surg Rehabil*. 2010;1(1):6–14.
11. Panula J, Pihlajamaki H, Mattila VM, et al. Mortality and cause of death in hip fracture patients aged 65 or older: a population-based study. *BMC Muscoskel Disord*. 2011;12:105.
12. Antonova E, Boye ME, Sen N, O'Sullivan AK, Burge R. Can bundled payment improve quality and efficiency of care for patients with hip fractures? *J Aging Soc Pol*. 2015;27(1):1–20.
13. Di Capua J, Somani S, Kim JS, et al. Predictors for patient discharge destination after elective anterior cervical discectomy and fusion. *Spine*. 2017;42(20):1538–1544 (Phila Pa 1976).
14. Bohl DD, Ondeck NT, Basques BA, Levine BR, Grauer JN. What is the timing of general health adverse events that occur after total joint arthroplasty? *Clin Orthop Relat Res*. 2017;475(12):2952–2959.
15. Bohl DD, Webb ML, Lukasiewicz AM, et al. Timing of complications after spinal fusion surgery. *Spine*. 2015;40(19):1527–1535 (Phila Pa 1976).
16. De la Garza Ramos R, Goodwin CR, Passias PG, et al. Timing of complications occurring within 30 Days after adult spinal deformity surgery. *Spine Deform*. 2017;5(2):145–150.
17. Roser L, Altpeter T, Anderson D, Dougherty M, Walton JE, Merritt S. A nurse driven foley catheter removal protocol proves clinically effective to reduce the incidents of catheter related urinary tract infections. Am J Infect Contr.40(5):e92-e93.
18. Durant DJ. Nurse-driven protocols and the prevention of catheter-associated urinary tract infections: a systematic review. *Am J Infect Contr*. 2017;45(12):1331–1341.