RESEARCH ARTICLE

Temporal Trends in Hip Fractures: How Has Time-to-Surgery Changed?

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Abstract

Background: Surgical fixation of hip fractures within 24–48 hours of hospital presentation is associated with decreased rates of postoperative morbidity and death, and recently, hospitals nationwide have implemented strategies to expedite surgery. Our aim was to describe how time-to-surgery and short-term complication rates have changed using the National Surgical Quality Improvement Program database from 2011 to 2017.

Methods: We identified more than 73,000 patients aged ≥65 years who underwent surgical fixation. Poisson regression adjusting for comorbidities, surgery type, type of anesthesia, patient sex, and patient age was performed to quantify annual changes in time-to-surgery. Annual changes in 30-day postoperative complications were analyzed using a generalized linear model with binomial distribution.

Results: A significant decrease in time-to-surgery was observed during the study period (mean 30 hours in 2011 versus 26 hours in 2017; *P<0.001*). Time-to-surgery decreased by 2% annually during the 7-year period (0.5 hour/year, 95% CI: -35, -23; *P<0.001*). The all-cause 30-day complication rate also decreased annually (annual risk difference: −0.35%, 95% CI: −0.50%, −0.20%; *P<0.001*). For individual complications, we found significant decreases in deep infection (-0.2%, *P=0.002*), reintubation (-0.3%, *P=0.001*), urinary tract infection (-2.5%, *P<0.001*), and death (-1.3%, *P=0.03*). We found significant but small increases of pulmonary embolism (0.3%, *P=0.03*) and myocardial infarction (0.1%, *P=0.02*). Higher rates of complications were associated with increased time-to-surgery (*P<0.001*).

Conclusion: From 2011 to 2017, time-to-surgery for hip fracture decreased significantly, as did short-term postoperative rates of all-cause complications and death. Longer time-to-surgery was associated with increased number of complications.

Level of evidence: III

Keywords: Complications, Hip fracture, National surgical quality improvement program, Surgical fixation

Introduction

While the incidence of hip fractures has steadily declined in the US, their associated healthcare costs remain a major burden to the US healthcare system with expected costs to continue to rise over the next decade (1-3). During this same period, several studies have shown that early surgical fixation within 24 to 48 hours may lead to decreased morbidity and mortality, which may decrease associated healthcare costs (4-8). Benefits of early fixation include shorter hospital stays, lower rates of inpatient complications, and faster return to independent living (9). In a meta-analysis of more than 190,000 patients, early fixation of hip

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fractures was also associated with lower rates of death (5). In response to these observations, hospitals have employed several strategies aiming to reduce the time from admission to surgery with the intent of improving patient outcomes; however, periodic reassessment measuring the success of recent efforts in decreasing time-to-surgery and how patient outcomes are affected are needed (10).

Decreasing time-to-surgery for hip fractures has important implications not only for patients and healthcare teams, but also for hospital managers who must justify resource allocations to support early surgery (11). Several factors are involved in decreasing time-to-surgery, and it is difficult to determine which are the most successful because hospital environments differ greatly from one another. Because hospital heterogeneity precludes an accurate national assessment of which factors may lead to the greatest decrease in time-to-surgery, our aim was to determine whether hospitals nationwide have seen decreased times-to-surgery overall and if there has been a correlation with decreased short-term morbidity and mortality.

Materials and Methods

Cohort Selection

This study was exempt from IRB review. We queried the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database to identify patients who underwent surgical fixation of hip fracture from January 2011 through December 2017. Heterogeneous data and small sample sizes precluded analysis of years before 2011. We identified 85,311 patients using the following Current Procedural Terminology (CPT) codes: 27235 (percutaneous fixation), 27236 (open treatment of femoral neck fracture, e.g. hemiarthroplasty), and 27244 or 27245 (open reduction and internal fixation or intramedullary nailing for intertrochanteric, peritrochanteric, or subtrochanteric fractures). We excluded 11,435 patients aged <65 years and 763 extreme outliers in time to surgery (>99th percentile, i.e., ≥168 hours), leaving 73,113 patients for analysis [Figure 1].

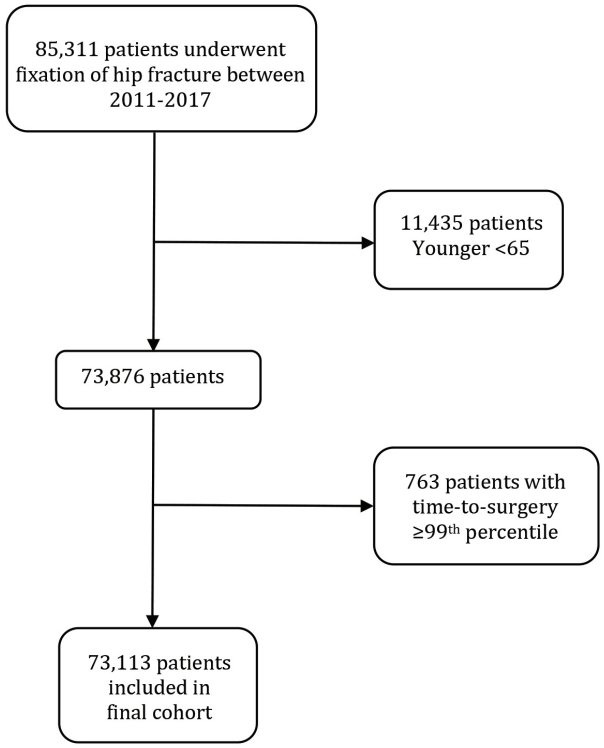

Figure 1. Patient's selection flow chart showing identification of cohort who underwent surgical fixation for hip fractures from 2011 through 2017.

Patient Characteristics

The median patient age was 87 years, and 72% of patients were women [Table 1]. The most frequent procedures were intramedullary nailing (47%) and open treatment of femoral neck fracture/hemiarthroplasty (36%). We also extracted data on race, BMI, and calculated modified Charlson Comorbidity Index (CCI) values adapted to the NSQIP database (12).

Table 1. Characteristics of 73,113 Patients who Underwent Surgical Fixation for Hip Fractures in the US, National Surgical Quality Improvement Program, 2011–2017

Variable		No. (%)
Age (*Median, years)		87
Gender		
	Female	52,560 (72%)
Race		
	White	54,285 (74%)
	African American	1,948 (3%)
	Other**	2,242 (3%)
	Unknown	14,638 (21%)

Table 1. Continued

Current Smoker		6,539 (9%)
BMI***		
	<18.5	14,182 (20%)
	18.5 - 24.9	30,663 (42%)
	25 - 29.9	17,960 (25%)
	>30	9,517 (13%)
Surgery		
	Open Treatment of femoral neck fracture (e.g. hemiarthroplasty)	26,517 (36%)
	ORIF of intertrochanteric, peritrochanteric or subtrochanteric fracture	11,522 (16%)
	IMN of intertrochanteric, peritrochanteric or subtrochanteric fracture	34,820 (48%)
	Percutaneous fixation of femoral neck fracture	254 (0.3%)
Modified Charlson Comorbidity Index****		
	3	4,156 (6%)
	4	14,228 (20%)
	5	29,800 (41%)
	6	24,929 (34%)

*Standard deviation cannot be computed as NSQIP reports >90 for patients older than 90 as opposed to their actual age; mean age was 82±7 years when changing those patients to 90 years of age. **Other constitutes American Indians, Alaska native, Asian and Native Hawaiian. ***BMI data missing for 1.1% (n=791) of patients. ****Minimum value for modified Charlson comorbidity index is 3 due to inclusion of only patients older than 65.

Outcomes of Interest

Outcomes of interest were time-to-surgery, which we defined as the number of hours from hospital admission to start of surgery, and complications occurring within 30 days after surgery. We analyzed the following complications: superficial or deep wound infection, wound dehiscence, pneumonia, reintubation, pulmonary embolism, renal failure, urinary tract infection, stroke, myocardial infarction, cardiac arrest, and death.

Statistical analysis

Descriptive statistics were reported as mean ± standard deviation and count (percent) for continuous and categorical variables, respectively. To determine changes in time-to-surgery from 2011 to 2017, a multivariable linear regression analysis was performed adjusting for age, CCI, sex, procedure type, and type of anesthesia. To determine significant variability over time in the rates of individual complications, we used a Cochrane-Armitage test for trend. We also evaluated changes in all-cause complication rates with a generalized linear model with binomial distribution. To determine whether increased time-to-surgery was associated with higher complications rates, an analysis of variance with Tukey's multiple comparison test was used. Analyses were conducted using SAS, version 9.4, software (SAS Institute Inc., Cary, NC). Significance was set at $P < 0.05$.

Results

Time-to-Surgery

Mean ± standard deviation time-to-surgery decreased significantly, from 30 ± 28 hours in 2011 to 26 ± 24 hours in 2017 ($P < 0.001$) [Figure 2]. After adjusting for age, sex,

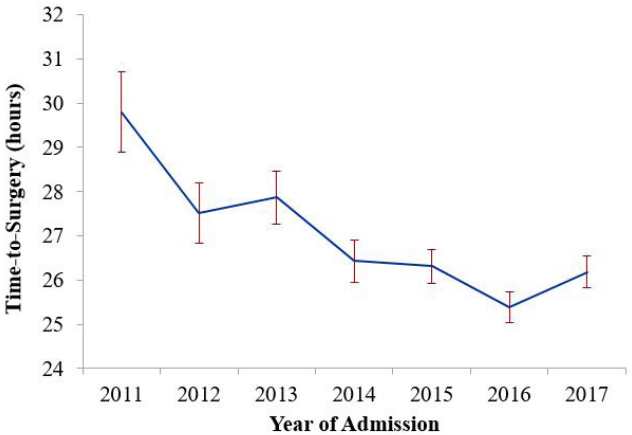

Figure 2. Annual mean time-to-surgery for 73,113 patients in the US with hip fractures showing a progressive downward trend, *P<0.05*. National Surgical Quality Improvement Program, 2011–2017. Error bars, 95% confidence intervals.

Table 2. Univariate Analysis of Complication Rates after Surgical Fixation of Hip Fracture in 73,113 Patients in the US, National Surgical Quality Improvement Program, 2011–2017

Complication	N (%)		*P Value*
	2011	2017	
Cardiac arrest	28 (0.8)	135 (0.8)	0.36
Death	217 (6.3)	936 (5.5)	0.03
Myocardial infarction	69 (2.0)	350 (2.1)	0.02
Pneumonia	131 (3.8)	682 (4.0)	0.50
Pulmonary embolism	19 (0.5)	145 (0.8)	0.03
Reintubation	49 (1.4)	118 (1.1)	0.001
Renal failure	12 (0.35)	59 (0.35)	0.12
Stroke	22 (0.6)	135 (0.8)	0.12
Surgical site deep infection	14 (0.4)	29 (0.2)	0.002
Surgical site superficial infection	25 (0.72)	121 (0.7)	0.188
Urinary tract infection	230 (6.7)	719 (4.2)	<0.001
Wound dehiscence	4 (0.1)	15 (0.1)	0.66

race, CCI, type of anesthesia, and procedure, there was an annual 2% decrease in time-to-surgery (0.5 hour/year, 95% CI: -35, -23; *P < 0.001*). Over the 7 year study period, there was a total 13% decrease in time-to-surgery (3.9 hours, 95% CI: -286, -177).

Complication Rates

From 2011 to 2017, we found a significant decrease in the rates of deep wound infection (*P<0.001*), reintubation (*P=0.001*), urinary tract infection (*P<0.001*), and death (*P=0.03*) [Table 2]. We found small but significant increases in the rates of pulmonary embolism (*P=0.03*) and myocardial infarction (*P=0.02*). There were no significant differences in any other complications evaluated. We found a significant annual decrease in the all-cause complication rate after adjusting for age, sex, race, CCI, anesthesia type and procedure type (annual risk difference: −0.4%; 95% CI: −0.5%, −0.2%; *P<0.001*). Finally, higher rates of complications were associated with increased time-to-surgery (*P<0.001*) [Table 3].

Table 3. Number of Complications Experienced in 73,113 Patients in the US treated for hip fracture by Time-to-Surgery, National Surgical Quality Improvement Program, 2011–2017

No. of Complications	*Time-to-surgery (± standard deviation)
0	26.4 ± 24.0
1	29.7 ± 27.1
2	31.3 ± 28.2
>=3	33.8 ± 29.2

*Mean time expressed in hours (*P < 0.001*).

Discussion

We found a cumulative 4-hour decrease in time-to-surgery from 2011 to 2017 for patients undergoing hip fracture fixation that correlated with decreased 30-day postoperative rates of deep infection, reintubation, urinary tract infection, and death. Further, increased time-to-surgery was associated with increased complications rates. These results may be used to support the allocation of healthcare resources for optimizing hip fracture care. Lowered rates of complications and death may yield considerable savings in both patients' lives and hospital expenditure.

Adopting comprehensive hip fracture care pathways to safely reduce time-to-surgery and post-operative complications is critical for hospitals to succeed in a new climate of value-based care. In 2018, the Centers for Medicare & Medicaid Services implemented an optional bundled payment system, the Bundled Payments for Care Improvement Advance Model (13, 14). The system is intended to encourage providers and administrators to redesign and adopt care pathways to reduce costs and improve patient outcomes often through expedited surgery. However, as these pathways become wide spread, avenues for identifying high-risk and comorbid patients who may need extended work-up or delayed surgery remains vital. Healthcare expenditure for these patients may vastly exceed their counterparts (15-17). Thus far, institutions that have successfully adopted perioperative protocols for hip fracture management have reported significant cost savings as well as additional sources of revenue through bundled payment (13).

In our analysis, the rates of two complications increased, but these increases were small (0.3% for pulmonary embolism and 0.1% for myocardial infarction). Several studies have shown that increased rates of pulmonary embolism may be attributed to both over-diagnosis as well as improved CT technology, with no change in pulmonary embolism-specific mortality (18-21). However, peri-operative myocardial infarction remains an important and independent contributor to mortality and continued optimization is required to avoid this complication (22).

Early or expedited surgery may not be possible for elderly patients with multiple comorbidities because medical optimization and further preoperative testing may be needed. Although a large meta-analysis of more than 190,000 patients showed decreased postoperative morbidity and mortality associated with surgery within 24 to 48 hours, it is difficult to account for confounders, such as comorbidities necessitating further testing, that may have caused delays in surgery for patients who underwent surgery >48 hours after presentation (5). In a study of 250 elderly patients with hip fractures, additional preoperative testing (including echocardiography, cardiac stress testing, carotid ultrasonography, rule-out of myocardial infarction, electroencephalography, implantable cardioverter defibrillator interrogation, and endoscopy) was performed for 67 patients, and only 2 of these patients were offered further care based on the testing results (23). Patients who underwent additional testing had a longer mean time to surgery (73 hours)

compared with those who did not (37 hours), as well as a longer hospital stay (12 vs. 9 days). These findings suggest that routine extended preoperative testing beyond basic work-up may not necessarily improve outcomes but rather lead to delayed surgery and extended hospital stay. However, the decision to pursue additional preoperative testing before surgery should be weighed carefully on a case-by-case basis.

Strategies to expedite surgery depend on several factors, each of which can vary between hospitals (11). In addition to hospital resources, such as operating rooms, surgical and nursing staff, medical specialists, and laboratory/imaging tests, other factors may delay time to surgery. For example, transferring patients to another hospital has been shown to significantly delay surgery. In a study of more than 49,000 hip fracture patients, 14% required inter-hospital transfer and were 3.2 and 2.6 times more likely to wait ≥5 and 2–4 days, respectively, before surgery (24). The time of day when patients arrive at the hospital is also associated with surgical timing. Because of hospital staffing and surgeon preference, nighttime surgeries may be deferred to the day; however, a study found no significant differences in mortality rates up to 2 years postoperatively between patients who underwent surgery during the day versus night (25). Finally, patient fitness and comorbidity exacerbation may also delay surgery to allow medical optimization.

There are limitations with this study. Recording of postoperative complications can be inaccurate in large databases (26). However, NSQIP may be a more accurate source of data than administrative databases, such as the National Inpatient Sample, or private analytics databases (27). We may not have captured all patients with a hip fracture during the study period because CPT code 27125 is commonly but erroneously used to bill for hip fracture treatment. It describes hemiarthroplasty performed for degenerative changes and not traumatic causes; however, it has been used by other authors to identify patients with hip fracture (28). We assessed the temporal changes in time-to-surgery during a 7-year period because heterogeneous data and small sample sizes precluded analysis before 2011. Because this study relies on national survey data, it is unclear which hospital policies may have contributed to the greatest changes in time-to-surgery. Finally, these findings are observational and do not suggest causation.

In summary, we found that time-to-surgery and the rates of all-cause 30-day postoperative complications decreased from 2011 to 2017 for patients who underwent surgical fixation of hip fractures in the US. Although additional research is needed to determine which factors play the largest roles in optimizing outcomes and decreasing surgical timing, these encouraging results may motivate continued adoption of hip fracture care pathways and justify resource allocation to this cause.

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