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A three-year retrospective multi-center study on time to surgery and mortality for isolated geriatric hip fractures

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ABSTRACT

Background: There are multiple reports on the effect of time to surgery for geriatric hip fractures; it remains unclear if earlier intervention is associated with improved mortality, hospital length of stay (HLOS), or cost.
Methods: This was a multi-center retrospective cohort study. Patients (≥65y.) admitted (1/14-1/16) to six level 1 trauma centers for isolated hip fractures were included. Patients were dichotomized into early (≤24 h of admission) or delayed surgery (>24 h). The primary outcome was mortality using the CDC National Death Index. Secondary outcomes included HLOS, complications, and hospital cost.
Results: There were 1346 patients, 467 (35%) delayed and 879 (65%) early. The early group had more females (70% vs. 61%, $p < 0.001$) than the delayed group. The delayed group had a median of 2 comorbidities, whereas the early group had 1, $p < 0.001$. Mortality and complications were not significantly different between groups. After adjustment, the delayed group had no statistically significant increased risk of dying within one year, OR: 1.1 (95% CI:0.8, 1.5), compared to the early group. The average difference in HLOS was 1.1 days longer for the delayed group, when compared to the early group, p-diff<0.001, after adjustment. The average difference in cost for the delayed group was $2450 ($1550, $3400) more expensive per patient, than the early group, $p < 0.001$.
Conclusions: The results of this study provide further evidence that surgery within 24 h of admission is not associated with lower odds of death when compared to surgery after 24 h of admission, even after adjustment. However, a significant decrease in cost and HLOS was observed for early surgery. If causally linked, our data are 95% confident that earlier treatment could have saved a maximum of $1,587,800. Early surgery should not be pursued purely for the motivation of reducing hospital costs.
Level of evidence: Level III.

Abbreviations: TQIP, Trauma Quality Improvement Program; HLOS, Hospital Length of Stay; CDC NDI, Centers for Disease Control National Death Index; AUC, area under the curve; IQR, interquartile range; SD, standard deviation; AIS, Abbreviated Injury Scale; COPD, chronic obstructive pulmonary disease; RR, respiratory rate; SBP, systolic blood pressure; ASA, American Society of Anesthesiologists; ACE, angiotensin-converting enzyme; CI, confidence interval; OR, odds ratio; AOR, adjusted odds ratio; AAOS, American Academy of Orthopedic Surgeons; SE, standard error.

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1. Introduction

Current guidelines from the American College of Surgeons Trauma Quality Improvement Program (TQIP) and American Academy of Orthopaedic Surgeons (AAOS) recommend surgery within 48 h of admission for geriatric patients with hip fractures.[1,2] Many studies have compared the effect of time to surgery on outcomes, with some suggesting earlier surgery improved mortality rates, reduced hospital length of stay (HLOS), reduced rates of pneumonia, ulcers, and pressure sores.[3–10] Conversely, other studies have found no increase in mortality or morbidity rates for geriatric patients with hip fractures who undergo delayed surgery.[11–20] However, these studies have varying definitions for early surgery ranging from 6 to 48 h from admission.[3–20] The studies using a 48-h cut-off for comparing time to surgery, typically reported no difference in outcomes, whereas studies with shorter definitions for early surgery (24 h or less) typically reported differences in outcomes, specifically for mortality.[5–12,16,18,19] Khan et al. conducted a systematic review of 52 studies and re-evaluated the effect of time-to-surgery on mortality and complications.[21] They concluded that early surgery was associated with reduced HLOS, but had conflicting results on mortality and morbidity.[21] The authors also noted that only 25 studies adjusted for confounding variables and many had small sample sizes.[21] One study found that the average cost of delayed intervention was significantly higher than that of early intervention, when comparing expeditated surgery, patients who went to surgery within 6 h of admission, to "late surgery" those who went to surgery more than 6 h of admission; it is important to determine if this remains true when defining early surgery as surgery within 24 h.[22] The purpose of this study was to compare long term mortality and hospital costs for early versus delayed surgery within our network of six level 1 trauma centers, utilizing a large sample size to sufficiently adjust for confounding variables. Additionally, we looked at comparing the two cohort groups for HLOS and complications.

2. Materials and methods

This was a multi-center retrospective cohort study at six level 1 trauma centers in four states. This study was approved by all six institutional review boards (IRB). The study IRB numbers are as follows: 994116 (Medical City Plano), 1182847 (Research Medical Center), 973888 (Swedish Medical Center), 1030992 (St. Anthony Hospital), 975847 (Penrose Hospital), and 18-013 (Wesley Medical Center). Geriatric patients (aged $\geq$ 65 years old) with isolated hip fractures admitted from January 1, 2014 to January 1, 2017 were included in the study. Patients with an abbreviated injury scale (AIS) score of $\geq$ 2 in any other anatomical region and patients who did not have surgical treatment for their hip fracture were excluded. ICD-9 and ICD-10 diagnosis codes for hip fractures were used to identify patients from each trauma center's trauma registry. The trauma registries utilized included: Digital Innovations V4 (Research Medical Center through 2015 and Wesley Medical Center through 2015) and Digital Innovations V5 (Research Medical Center 2015 forward, Wesley Medical Center 2015 forward, and Swedish Medical Center 2016 forward), TraumaBase (Medical City Plano entire study duration, Penrose through 2016, St. Anthony Hospital through 2016, and Swedish Medical Center through 2016) and TraumaONE (Penrose Hospital 2016 forward and St. Anthony Hospital 2016 forward).

Patients were dichotomized into early surgery (defined as surgery $\leq$ 24 of admission) or delayed surgery (defined as surgery > 24 h of admission). The primary outcome was mortality assessed in-hospital, at three-months, six-months, and one-year after admission. Mortality was cumulative, for example six-month mortality includes the in-hospital deaths and deaths up to three-months. Mortality data was obtained from the Centers for Disease Control and Prevention (CDC) National Death Index (NDI). The CDC NDI provides exact and potential matches for all patient data provided; only exact mortality matches were included. Secondary outcomes were HLOS, in-hospital complications, and total hospital cost. In-hospital complications included: urinary tract infections, sepsis, thromboembolic complications, return to the ICU, return to the operating room, pneumonia, myocardial infarction, cardiac arrest, and unplanned intubation. Thromboembolic complications included: deep vein thrombosis, stroke, and pulmonary embolism.

The total hospital costs comprised of direct and indirect expenses to the hospital. Direct expenses included: supplies, purchased services, labor (registered nursing, technicians, management, support, and contract), benefits, physician renumeration, non-patient revenues (offset), laundry and printing. Indirect expenses included: hospital labor (staffing, housekeeping), depreciation, amortization and interest, overhead administration, overhead support, and overhead facility. Costs are rounded to the nearest $50. All documented pre-hospital, discontinued, in-hospital, and discharge medications were collected, only medications that were significantly different between groups are presented. Mortality rates were stratified by the median comorbidity count across all patients, 0–2 comorbidities versus $\geq$3 comorbidities.

2.1. Statistics

Data are summarized as proportions (counts) for categorical and dichotomous data, means (standard deviation) or median (interquartile range) for continuous data, based on distribution. Chi-squared or Fisher's exact test were used to compare categorical and dichotomous data. Kruskal-Wallis or Student's t-tests were used to compare continuous data. Linear mixed-effects regression and stepwise logistic regression were used to determine if outcomes were independently associated with time to surgery. Enrolling facility was included as a random effect. Regression models were conducted for outcomes with sufficient counts to adjust for various confounders. Stepwise regression was used with an entry criterion of 0.25 and exit criterion of 0.05. Variables available to the stepwise models were significantly associated with the outcome of interest. The receiver operating characteristics area under the curve (AUC) was used to determine the optimal time to surgery when considering long term mortality. A sample size of 1178 was calculated to achieve a power of 80% for a two-tailed chi-squared test; however additional patients were requested in order to adjust for various confounders.[13] An alpha of 0.05 was used.

3. Results

There were 1346 patients enrolled in the study; 467 (35%) in the delayed group and 879 (65%) in the early group. Overall 67% of the patients were female and the median (IQR) age was 83 years old (76, 89). There was a higher proportion of females in the early group than the delayed group, 70% vs 61% respectively, $p < 0.001$, Table 1. Patients in the delayed group had significantly more comorbidities than patients in the early group. Delayed patients had a median of 2 (1, 3) comorbidities, whereas early patients had a median of 1 (1, 2) comorbidity, $p < 0.001$. There was a significantly higher proportion of delayed patients with a bleeding disorder, hypertension, congestive heart failure and steroid use than in the early group. No other demographic or clinical differences were observed; however, there were differences in medication use between the two groups.

There were also a higher proportion of patients in the early group taking Vitamin D (26%) than in the delayed group (18%, $p < 0.001$), Table 2. The count of pre-injury medications was not significantly different between groups. There were a higher proportion of patients in the delayed group (21%) who were taking pre-injury anticoagulants than in the early group (11%, $p < 0.001$). Likewise, there were also a higher proportion of patients in the delayed group with their anticoagulant discontinued (6%) than there were in the early group (2%), $p < 0.001$. There were a higher proportion of patients in the delayed group given in-hospital muscle relaxers (6%) than in the early group (3%), $p = 0.02$, and there were a higher proportion of patients in the delayed group who were given muscle relaxers at discharge (12%) than the in the early group (6%), $p < 0.001$. A higher proportion of patients in the early group were prescribed narcotics at discharge (74%) than in the delayed group (60%), $p < 0.0001$.

Fracture types were similar between groups, except that there were a higher proportion of patients in the delayed group, 52%, with a neck of femur fracture than in the early group, 46%, $p = 0.04$, Table 3. There was a significantly higher proportion of patients in the delayed group than in the early group who had a hip arthroplasty (36% versus 29%) and open reduction (18% versus 12%), $p = 0.004$ and $p = 0.004$, respectively. Other procedure types were similar between groups. The median time to surgery was 13.9 h (6.3, 18.9) for the early group and 36.8 (28.4, 45.1) for the delayed group.

In hospital complications were also comparable between groups, except there was a higher proportion of patients in the delayed group (2%) who had a urinary tract infection than in the early group (0%), $p = 0.01$, Table 4. Patients in the delayed group were discharged home or to home with health care services (27%) more often than the early group (21%), and the delayed group were likely to be discharged to rehab (29%) than the early group (15%), $p = 0.0002$, however after adjustment there was no difference in the odds for discharge disposition.

The delayed group had a higher proportion of patients who died in-hospital, at three months after admission, at six months after

Table 2
Patient medications by treatment group.

	Early n = 879	Delayed n = 467	p
Pre-Injury Medication			
Vitamin D	26% (23)	18% (83)	<0.001
Anticoagulant	11% (96)	21% (98)	<0.001
Vitamin E	3% (26)	1% (4)	0.01
Pre-injury Medication Count	7 (4, 10)	7 (4, 10)	0.66
Discontinued Medications			
Diuretic	2% (19)	5% (25)	0.002
Antiplatelet	5% (42)	7% (35)	0.04
Insulin	1% (10)	3% (12)	0.048
Anticoagulant	2% (16)	6% (28)	<0.001
Antihistamine	0% (3)	2% (7)	0.04
ACE inhibitor	2% (16)	5% (23)	0.001
In-hospital Medications			
Muscle Relaxer	3% (30)	6% (29)	0.02
Vitamin K	0	1% (4)	0.01
ACE inhibitors	0% (2)	1% (6)	0.02
New Medications at Discharge			
Narcotic	74% (650)	60% (280)	<0.001
Hypertensive	3% (25)	4% (17)	0.04
Anemia	7% (61)	4% (2)	0.05
Anti-arrhythmia	1% (12)	4% (18)	0.00
Anticoagulant	74% (654)	66% (306)	0.00
Long-acting Bronchodilator	1% (5)	3% (12)	0.002
Anti-inflammatory	6% (49)	8% (39)	0.05
Antiplatelet	5% (40)	7% (35)	0.03
Muscle Relaxer	6% (55)	12% (57)	<0.001

ACE: angiotensin-converting enzyme.

Table 1
Demographic and clinical characteristics.

	Early n = 879	Delayed n = 467	p
Age in years Median (IQR)	83 (76, 89)	83 (76, 89)	0.62
Sex Female % (n)	70% (618)	61% (285)	<0.001
Residence at Admission			
Assisted Living	12% (108)	13% (60)	0.65
Home	74% (641)	71% (329)	
Skilled Nursing Facility	11% (96)	12% (55)	
Group Home	0% (1)	0% (2)	
Independent Living Facility	2% (13)	2% (11)	
Inpatient Rehab	0% (3)	1% (3)	
Memory Care	1% (7)	1% (4)	
Comorbidities			
Bleeding Disorder	10% (92)	14% (66)	0.047
Diabetes	12% (106)	11% (52)	0.62
Hypertension	54% (476)	60% (280)	0.04
Congestive Heart Failure	6% (54)	10% (46)	0.01
Smoker	6% (50)	5% (21)	0.35
Dementia	20% (177)	22% (105)	0.31
Cerebrovascular Accident	6% (50)	7% (33)	0.32
Kidney Disease	2% (21)	4% (17)	0.19
Steroid Use	2% (19)	6% (26)	<0.001
COPD	6% (52)	7% (35)	0.26
Comorbidity Count Median (IQR)	1 (1, 2)	2 (1, 3)	<0.001
Admission Heart Rate Median (IQR)	80 (70, 90)	80 (70, 89)	0.56
Admission RR Median (IQR)	18 (16, 18)	18 (16, 18)	0.08
Admission SBP Mean (SD)	151.6 (28.0)	151.2 (29.3)	0.79
Admission Temperature Median (IQR)	36.7 (36.4, 36.8)	36.6 (36.3, 36.9)	0.89
ASA Score			
1	0% (4)	0% (2)	0.09
2	20% (169)	15% (67)	
3	65% (560)	68% (313)	
4	14% (124)	17% (79)	

IQR: interquartile range, n = number of patients, COPD: chronic obstructive pulmonary disease, SD: standard deviation, RR: respiratory rate, SBP: systolic blood pressure, ASA: American Society of Anesthesiologists.

Table 3
Hip fracture and surgical procedure information.

	Early n = 879	Delayed n = 467	p
Fracture Type			
Neck of Femur	46% (404)	52% (242)	0.04
Intertrochanteric	38% (338)	33% (155)	0.06
Subtrochanteric	2% (17)	2% (10)	0.80
Procedure*			
Arthroplasty	29% (253)	36% (170)	0.004
Internal Fixation	66% (577)	61% (286)	0.11
Open Reduction	12% (106)	18% (83)	0.004
Closed Reduction	6% (49)	8% (37)	0.09
External Fixation	0% (3)	1% (4)	0.25
Splint	1% (9)	1% (4)	>0.99
Time to Procedure Median (IQR)	13.9 (6.3, 18.9)	36.8 (28.4, 45.1)	<0.001

*Some patients had more than one procedure for their hip fracture.

admission, and at one year after admission; however, none of the differences were statistically significant. One-year mortality rates were 21% for the delayed group compared to a 17% mortality rate for the early group, however this was not statistically significant, p = 0.052. After adjustment for enrolling facility, congestive heart failure, gender, and age the delayed group had 1.1 times (95% CI:0.8, 1.5) the odds of dying within one year, compared to the early group, however this difference was not statistically significant. The median (IQR) HLOS was significantly longer for the delayed group, 5 days (3, 6), when compared to the early group, 3 days (3, 5), p < 0.0001. After adjustment for having congestive heart failure, the HLOS was an average (CI) of 1.1 days (0.6, 1.6) longer for the delayed group when compared to the early group, p-diff<0.001. Mortality rates were stratified by the overall patient comorbidity count; there were no significant difference in mortality rates for early versus delayed surgery after stratification.

The total cost to the hospital to treat the delayed group was an average (CI) of $3200 (2300, 4150) more expensive per patient, than the early group. After adjustment for enrolling facility, the LS mean difference (CI) in cost to treat the delayed group was an additional $2450 (1550, 3400) when compared to the early group, p-diff<0.001. If causally linked, our data are 95% confident that earlier treatment for all 467 patients who received delayed surgery could have saved a maximum of $1,587,800.

When examining time to surgery as a continuous predictor, time to surgery for geriatric patients was a poor predictor of in-hospital mortality, AUC (CI) = 0.54 (0.41, 0.67), (Table 5). Time to surgery was slightly better than chance at predicting one-year mortality, AUC (CI) = 0.60 (0.54, 0.67).

4. Discussion

The results of this study indicate that surgical delay is not associated with short or long-term mortality or in-hospital complications. There was a higher rate of urinary tract infections in the delayed group, though due to the small number of patients with urinary tract infections, we were unable to adjust for potential confounders. Alternatively, there was a significant difference in the HLOS and total hospital cost for the early surgical group when compared to the delayed group. Some have suggested that patient comorbidities may be the factor driving increased mortality rates

Table 5
Optimal time to surgery when considering mortality.

Outcome	AUC (CI)	Model p-value	Covariate p-value
In-hospital	0.54 (0.41, 0.67)	0.55	0.67
Three-month	0.61 (0.52, 0.70)	0.02	0.57
Six-month	0.61 (0.54, 0.68)	0.003	0.55
One-year	0.60 (0.54, 0.67)	0.002	0.47

AUC: area under the curve, CI: confidence interval.

Table 4
Outcomes and complications.

	Early n = 879 Reference Group	Delayed n = 467	p	OR (CI) Delayed Vs. Early	AOR (CI) Delayed Vs. Early
Complications					
Unplanned Return to the ICU	2% (15)	3% (14)	0.12	1.8 (0.9, 3.7)	0.9 (0.2, 4.5)[1]
Urinary Tract Infection	0% (3)	2% (9)	0.01	5.7 (1.5, 21.3)	N/A
Thromboembolism	1% (13)	1% (5)	0.53	0.7 (0.3, 2.0)	N/A
Cardiac Arrest with CPR	0% (3)	1% (4)	0.24	2.5 (0.6, 11.3)	N/A
Pneumonia	0% (3)	1% (3)	0.42	1.9 (0.4, 9.4)	N/A
Myocardial Infarction	1% (5)	0% (1)	0.67	0.4 (0, 3.2)	N/A
Unplanned Intubation	0% (2)	1% (3)	0.35	2.8 (0.5, 17.0)	N/A
Sepsis	0% (2)	0% (2)	0.61	1.9 (0.3, 13.4)	N/A
Discharge Location*					
Home/Home Health	21% (184)	27% (130)	0.0002	Ref.	Ref.
Rehab	15% (133)	29% (134)		1.4 (1.0, 2.0)	1.1 (0.7, 1.8)[2]
SNF	33% (289)	32% (149)		0.7 (0.5, 1.0)	1.1 (0.7, 1.7)[2]
In-hospital death	1% (11)	2% (9)		1.2 (0.5, 2.9)	1.1 (0.4, 3.0)[2]
Readmitted**	3% (30)	4% (19)	0.54	1.2 (0.7, 2.2)	N/A
CDC NDI Death Data					
In hospital	1% (11)	2% (9)	0.33	1.6 (0.6, 3.8)	1.4 (0.6, 3.4)[3]
Three-month	9% (78)	12% (56)	0.07	1.4 (0.9, 2.0)	1.3 (0.9, 1.9)[4]
Six-month	11% (101)	15% (69)	0.08	1.3 (1.0, 1.8)	1.2 (0.9, 1.7)[4]
One-year	17% (145)	21% (97)	0.052	1.3 (1.0, 1.8)	1.1 (0.8, 1.5)[5]
HLOS Median (IQR)	3 (3, 5)	5 (3, 6)	<0.0001	N/A	N/A
LS Mean (SE)	2.5 (0.3)	3.5 (0.3)	<0.0001[a]	N/A	N/A
LS Mean Diff. Adj. (CI)[3]	Ref.	1.1 (0.6, 1.6)	<0.0001[b]	N/A	N/A
Total Cost	UTR	UTR	<0.0001[a]	N/A	N/A
LS Mean Diff. (CI)	Ref.	$3200 (2300, 4150)	<0.0001[b]	N/A	N/A
LS Mean Diff. (CI) Adj.[1]	Ref.	$2450 (1550, 3400)	<0.0001[b]	N/A	N/A

OR = Odds ratio, AOR = adjusted odds ratio, CI: confidence interval, Ref = Reference, Diff. = Difference, SE = Standard error, IQR = interquartile range, CDC = Centers for Disease Control and Prevention, NDI = National Death Index, UTR = unable to report, Adj = adjusted. a = Model p-value, b = p-diff. 1 = adjusted for enrolling facility, 2 = adjusted for enrolling facility and age, 3 = adjusted for congestive heart failure, 4 = adjusted for congestive heart failure, age, discharge anticoagulants, 5 = adjusted for enrolling facility, congestive heart failure, gender, and age. All mortality time-points had the same variables available for stepwise regression models. *Remaining patients were discharged to some other facility, left against medical advice, or the disposition was missing. **Includes only patients readmitted because of the hip fracture.

and surgical delays.[14,23] In a stratified analysis of comorbidity count in this study there was no difference in mortality for those in the delayed surgery group when compared to those in the early surgery group.

Similar to the findings of this study, another previous study by Orosz et al. found that surgery within 24 h was not associated with improved mortality rates and recommended early surgery for patients who are medically stable when possible.[13] Grimes et al. also compared mortality rates in 24 h intervals and found no effect on time to surgery after adjustment.[3] Kenzora et al. compared mortality rates for early versus delayed surgery and concluded that medical conditions should be stable for at least 24 h before scheduling open surgical procedures.[20] Notably in this study the median time to surgery for the delayed group, 37 h, was still within the TQIP and AAOS guidelines of 48 h; it is possible that this may play a role in why no difference in mortality was observed in this study as the delayed group still went to surgery in a timely manner considering current guideline recommendations.[1,2] Factors other than decreasing the time from admission to surgery may be more important to decrease mortality rates than time to surgery.

In fact, our study additionally assessed time to surgery as a continuous predictor for mortality and the area under the curve revealed that time to surgery was a poor predictor of mortality, only slightly better than chance. One other study examined time to surgery continuously using cox proportional hazards and also found that time to surgery did not have a statistically significant effect on postoperative mortality, $p = 0.30$, RR:1.0 (0.99, 1.0).[14] The authors suggest a purposeful delay with the aim of improving the patient's condition to be considered before surgery and that other factors such as pre-ambulatory status and cognitive function have a greater impact on mortality.[14] Another study conducted by Pincus et al. looked at time to surgery as a continuous predictor for complications, but not for mortality, and found that 24 h may represent a threshold for defining risk; then compared mortality rates between patients who went to surgery within 24 h and patients who went to surgery after 24 h.[24] Although their study observed a smaller difference in mortality rates between the two groups, 19.3% for early patients and 21.6% for delayed patients, than seen in our study 17% for early patients and 21% for delayed patients, they observed a significant difference in mortality rates whereas this study did not.[24] This may be due to the rather large sample size included in the Pincus et al. study of 27,522 patients with an alpha of 0.05.[24]

Although we did not observe a significant decrease in mortality, we observed a decrease in the HLOS for geriatric patients with hip fractures treated in the early group. The HLOS in our study was an average of one day longer for the delayed group after adjustment. Bredahl et al. also looked at the HLOS and found a significant increase in HLOS for patients who received delayed surgery but did not adjust for confounding variables.[8] Orosz et al. compared outcomes for early versus delayed surgery, using 24 h as a definition for early surgery, and similarly found that early surgery was not associated with mortality but was associated with HLOS.[13] Orosz et al. also found that patients in the delayed surgery group stayed at the hospital an average of one day longer than the early surgery group, $p < 0.001$.[13] This difference in the HLOS observed in both studies, could be attributed to the time of surgical delay rather than an extended post-operative length of stay; however, data on the post-operative LOS would be needed to confirm this.[13] Leung et al. offer a reason that many studies investigate the time to surgery and that shortening pre-operative waiting time would likely result in a reduced HLOS, which relates to hospital resources utilized, hence, the financial burden of hospitalization.[25]

This study demonstrated that delayed surgery was associated with an average (CI) increase of $2450 in hospital costs. If causally linked these data are 95% confident that earlier treatment for all 467 who received delayed surgery could have saved a maximum of $1,587,800. Although it may be less expensive for the hospital to treat these patients by early surgery, there could be other hospital departments impacted increasing the hospital costs, such as rescheduling of elective procedures and extended labor expenses. Rushing surgery for geriatric hip fractures could impact operating room availability to treat other patients due to changing the operating room schedule. In fact, one study that examined the reason for surgical delay in patients with hip fractures found the main reason for surgical delay was a lack of an available operating room.[12] Another study found that 2% of elective surgery cancellations were due to priority for emergency surgery, 42% were cancelled due to lack of OR space, 7% were rescheduled due to overbooking of surgeon or excessive wait times; these elective surgery cancellations could all ultimately be caused by hip fracture surgery.[26] The authors noted that cancellation of surgery carries a major cost implication due to wasted resources.[26] The TQIP guideline for geriatric hip fractures labels geriatric hip fracture surgery as urgent rather than emergent, stating that the volume of emergent surgical cases can at times compromise the timely repair of geriatric hip fractures, resulting in delayed surgery; therefore suggesting that other surgeries not be rescheduled for geriatric hip fracture surgery.[2] Physician and nurse shifts could potentially also be extended to care for these patients, perhaps unnecessarily. More data are needed to fully describe the extent of the hospital costs accumulated for each surgical group; though collecting these data would be difficult as they do not directly relate to the patients enrolled in the study.

This study has limitations, it was a retrospective observational study, therefore data could not always be validated. Nevertheless, we were able to more thoroughly account for patient comorbidities by also collecting data on pre-injury medications, and unlike prior studies, were able to adjust for confounding variables to determine if the time to surgery was independently affecting mortality.[21] It is possible that differences between the two groups are hidden due to unaccounted variables. Another limitation to typical retrospective studies is loss of follow-up, in effect to reduce loss of follow-up, data on long-term mortality data were collected from the CDC NDI, considered the gold standard for mortality data.[27,28]

5. Conclusions

The optimal time to surgery has yet to be defined for patients with geriatric hip fractures. However, our data suggest that reducing time to surgery may not reduce mortality or complications. We suggest early surgery for patients deemed medically safe, and not to push for earlier surgery in patients whom may benefit from stabilization prior to surgery. Thoughtful consideration of comorbidities and pre-injury medications for medical optimization should be undertaken to conduct surgery safely. Early surgery should not be pursued purely for the motivation of reducing hospital costs.

Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcot.2019.12.001.

References

1. AAOS. *Management of Hip Fractures in the Elderly Evidence-Based Clinical Practice Guideline*. 2014.
2. American College of Surgeons. *ACS TQIP Best Practices in the Management of Orthopaedic Trauma*. 2015:1–29.
3. Grimes JP, Gregory PM, Noveck H, Butler MS, Carson JL. The effects of time-to-surgery on mortality and morbidity in patients following hip fracture. *Am J Med*. 2002;112(9):702–709. https://doi.org/10.1016/S0002-9343(02)01119-1.
4. Basu N, Natour M, Mounasamy V, Kates SL. Geriatric hip fracture management: keys to providing a successful program. *Eur J Trauma Emerg Surg*. 2016;42(5): 565–569. https://doi.org/10.1007/s00068-016-0685-2.
5. Simunovic N, et al. Effect of early surgery after hip fracture on mortality and complications: systematic review and meta-analysis. *Can Med Assoc J*. 2010;182(15):1609–1616. https://doi.org/10.1503/cmaj.092220.
6. Dorotka R, Schoechtner H, Buchinger W. The influence of immediate surgical treatment of proximal femoral fractures on mortality and quality of life. *J Bone Jt Surg*. 2003;85(8):1107–1113. https://doi.org/10.1302/0301-620X.85B8.14282.
7. Hoerer D, Volpin G, Stein H. Results of early and delayed surgical fixation of hip fractures in the elderly: a comparative retrospective study. *Bull Hosp Jt Dis*. 1993;53(1):29–33.
8. Bredahl C, Nyholm B, Hindsholm KB, Mortensen JS, Oleson AS. Mortality after hip fracture: results of operation within 12h of admission. *Injury*. 1992;23: 83–86.
9. Sexson SB, Lehner JT. Factors affecting hip fracture mortality. *J Orthop Trauma*. 1987;1(4):298–305. https://doi.org/10.1097/00005131-198701040-00005.
10. Villar RN, Allen SM, Barnes SJ. Hip fractures in healthy patients: operative delay versus prognosis. *Br Med J*. 1986;293(6556):1203–1204. https://doi.org/10.1136/bmj.293.6556.1203.
11. Librero J, et al. Timing of surgery for hip fracture and in-hospital mortality: a retrospective population-based cohort study in the Spanish National Health System. *BMC Health Serv Res*. 2012;12:15. https://doi.org/10.1186/1472-6963-12-15.
12. Vidán MT, Sánchez E, Gracia Y, Marañón E, Vaquero J, Serra JA. Causes and effects of surgical delay in patients with hip fracture. *Ann Intern Med*. 2011;155(4):226. https://doi.org/10.7326/0003-4819-155-4-201108160-00006.
13. Orosz G, et al. Association of timing of surgery for hip fracture and patient outcomes. *JAMA, J Am Med Assoc*. 2004;291(14):1738–1743 6p.
14. Williams A, Jester R. Delayed surgical fixation of fractured hips in older people: impact on mortality. *J Adv Nurs*. 2005;52(1):63–69. https://doi.org/10.1111/j.1365-2648.2005.03565.x.
15. Dolk T. Operation in hip fracture patients–analysis of the time factor. *Injury*. 1990;21(6):369–372. https://doi.org/10.1016/0020-1383(90)90121-A.
16. Davis TRC, Sher JL, Porter BB, Checketts RG. The timing of surgery for intertrochanteric femoral fractures. *Injury*. 1988;19(4):244–246. https://doi.org/10.1016/0020-1383(88)90036-8.
17. Eiskjaer S, Ostgard SE. Risk factors influencing mortality after bipolar hemiarthroplasty in the treatment of fracture of the femoral neck. *Clin Orthop Relat Res*. 1991;(270):295–300.
18. Davie IT, Macrae WR, Malcolm-Smith NA. Anesthesia for the fractured Hip. *Anesth Analg*. 1970;49(1):165–170.
19. Aldrete J, Davis HS, Hingon RA. Anesthesia factors in the surgical management of hip fractures. *J Trauma*. 1967;7(6):818–826.
20. Kenzora JE, McCarthy RE, Loweell JD, Sledge CB. Hip fracture mortality. *Clin Orthop Relat Res*. 1984;186:45–56. https://doi.org/10.1007/s00198-010-1388-x.
21. Khan SK, Kalra S, Khanna A, Thiruvengada MM, Parker MJ. Timing of surgery for hip fractures: a systematic review of 52 published studies involving 291,413 patients. *Injury*. 2009;40(7):692–697. https://doi.org/10.1016/j.injury.2009.01.010.
22. Judd KT, Christianson E. Expedited operative care of hip fractures results in significantly lower cost of treatment. *Iowa Orthop J*. 2015;35:62–64.
23. Roche JJW. Effect of comorbidities and postoperative complications on mortality after hip fracture in elderly people: prospective observational cohort study. *BMJ*. 2005;331(7529). https://doi.org/10.1136/bmj.38643.663843.55, 1374-0.
24. Pincus D, et al. Association between wait time and 30-day mortality in adults undergoing hip fracture surgery. *JAMA, J Am Med Assoc*. 2017;318(20): 1994–2003. https://doi.org/10.1001/jama.2017.17606.
25. Leung F, Lau TW, Kwan K, Chow SP, Kung AWC. Does timing of surgery matter in fragility hip fractures? *Osteoporos Int*. 2010;21(SUPPL. 4):529–534. https://doi.org/10.1007/s00198-010-1391-2.
26. Chalya PL, et al. Incidence, causes and pattern of cancellation of elective surgical operations in a university teaching hospital in the Lake Zone, Tanzania. *Afr Health Sci*. 2011;11(3):438–443.
27. Sohn MW, Arnold N, Maynard C, Hynes DM. Accuracy and completeness of mortality data in the department of veterans affairs. *Popul Health Metrics*. 2006;4:1–8. https://doi.org/10.1186/1478-7954-4-2.
28. Lemay AC, Anzueto A, Restrepo MI, Mortensen EM. Predictors of long-term mortality after severe sepsis in the elderly. *Am J Med Sci*. 2014;347(4): 282–288. https://doi.org/10.1097/MAJ.0b013e318295a147.