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ORIGINAL ARTICLE

Outcomes of hip fracture surgery during the COVID-19 pandemic

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Abstract

Purpose To investigate if changes to hospital operational models during the COVID-19 pandemic negatively impacted overall time to surgery (TtS) as well as morbidity and mortality rates of hip fractures (HFx).

Methods 416 patients treated for OTA 31 fractures at a single institution between January 2019 and November 2020 were reviewed. TtS as well as morbidity and mortality rates were obtained from pre-pandemic and pandemic groups.

Results 263 patients were treated pre-pandemic and 153 were treated during the pandemic. There were no significant differences in median TtS, readmission rates ($p=0.134$), reoperation rates ($p=0.052$), 30-day ($p=0.095$) and 90-day ($p=0.22$) mortality rates.

Conclusion Reallocation of hospital resources in response to the COVID-19 pandemic did not negatively impact surgical timing or complications. TtS for HFx remains a challenge and often requires multidisciplinary care, which is complicated by a pandemic. However, this study demonstrates HFx standard of care can be maintained despite COVID-19 obstacles to treatment efficiency and efficacy.

Keywords COVID-19 · Hip fracture · Trauma · Morbidity · Mortality · Pandemic

Introduction

On March 2020 the World Health Organization (WHO) declared COVID-19 a global pandemic [1–4]. The virus and its potentially serious clinical manifestations, including death, placed sudden and extraordinary demands on healthcare facilities throughout the world [1–6].

Kumaraiah et al. describe how experts in respiratory management and critical care at New York-Presbyterian, such as anesthesiologists, were reassigned to critical care teams that were being overwhelmed by the massive influx of patients [7]. Wang et al. echoed this trend as staff from non-critical care areas at Mt. Sinai Hospital, including medical-surgical nurses and physical therapists, were asked to assist in various supportive capacities throughout the hospital to meet staffing shortages [7, 8]. At these training institutions, residents and fellows from various sub-specialties rotated through medical and critical care units in a combined effort to distribute workload [7, 8]. As hospitals diverted resources and care protocols were restructured in response to COVID-19, patients continued to sustain injuries that required time-sensitive orthopedic attention [9].

Pre-pandemic morbidity and mortality of hip fractures (HFx) have been extensively reviewed. The importance of time to surgery (TtS) for these injuries has been widely discussed. Studies suggest that surgical intervention within 24–48 h for geriatric HFx limits morbidity and mortality, with 1-year mortality rates as high as 20–25% [10–13]. Additional studies suggest an even firmer standard of care deadline of 24 h due to a correlated 7% increase in post-operative complications if intervention is delayed past this time point [12]. While strong evidence already supports TtS and its relation to decreased mortality, earlier surgery has also been associated with better overall functional outcome, shorter length of hospital stay, and decreased pain ratings while minimizing the duration of bed rest [12–15]. The authors' level 1 trauma center utilizes a multidisciplinary hip fracture protocol that centers on appropriately optimizing the patient while minimizing TtS. This hip fracture

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protocol consists of a dedicated medical team focused on perioperative clearances to help streamline patients to receive appropriate surgical care. Despite the reallocation of resources at our hospital during the pandemic, as was the case at institutions worldwide, our medical and orthopedic surgery teams continued to treat all-comers to the hospital, including patients presenting with HFx.

To our knowledge, there is limited literature that evaluates how reallocation of resources and implementation of new COVID-19 safety measures affected surgical throughput of time-sensitive orthopedic cases and overall outcomes [16–18]. This study addresses the knowledge gap by analyzing patients who sustained HFx during the pandemic and compare them to a cohort who presented prior to the pandemic. The primary purpose is to evaluate the pandemic's effect of changing hospital care protocols on time to surgery. The secondary purpose is to evaluate the effect on overall morbidity and mortality rates of HFx. This study will help elucidate how the challenges presented by the COVID-19 pandemic impacted the timing and outcomes of HFx surgery. Ultimately, the authors aim to improve outcomes for traumatic hip fracture patients by confirming if there was delay to treatment which resulted in poorer outcomes, identifying possible roadblocks, and opening up discussion for protocol implementation that can circumvent the obstacles that arise during a pandemic to better prepare orthopedic hospital operations for the future.

Patients and methods

Approval for this study was obtained from the Institutional Review Board. The institution's patient database was queried using Current Procedural Terminology (CPT) code to identify 544 adult patients treated for OTA 31 fractures between 1/2019 and 11/2020 at a Level 1 trauma center [19]. Inclusion criteria included patients aged 18 years and older who were treated for HFx, including femoral neck, intertrochanteric, and subtrochanteric femur fractures. Exclusion criteria included patients under 18 years old, elective cases, periprosthetic fractures, pathologic fractures, and those who had the index surgery at an outside institution. Of the 544 original patients, 416 patients met all inclusion and exclusion criteria. Patients were divided into two groups based on surgical timing either Pre-COVID to ($n=263$) or During-COVID ($n=153$) the pandemic. Patients who were treated through the end of 2/2020 were designated to the non-COVID control group (Pre-COVID). Patients treated after 2/2020, in line with the WHO's declaration of COVID-19 as a pandemic, were designated to the COVID group (During-COVID).

Retrospective chart review was performed for 416 patients. Primary outcome variables collected included TtS. Secondary outcome variables collected included discharge disposition, and 30-day, 90-day, and overall readmission, reoperation, and mortality rates. Relevant demographic data (gender, race, age distribution, smoking status, and BMI) were obtained for control purposes in detecting confounding factors that could mask or skew primary/secondary outcomes in this study. Specific postoperative complications were also evaluated to determine if it was a result of the surgical intervention or from a preexisting condition unique to the patient.

Statistical analysis was performed utilizing the Independent *T* test for parametric/continuous variables, Mann Whitney *U* test for non-parametric data, and chi-squared test for categorical variables. Linear and Logistic regressions were performed to investigate the relationship of independent factors to outcome. P-value < 0.05 defined statistical significance.

Results

Primary variables included time from admission to surgery which was not significant between the two groups. Median time was 22.0 h for Pre-COVID and 23.0 h for During-COVID (Table 3). Distribution of TtS remained relatively consistent between cohorts, with the 25th percentile for both groups at 17.0 h. The 75th percentile for TtS was 28.0 h for Pre-COVID and 32.0 h for During-COVID. Linear regression analysis demonstrated that TtS was not affected by the pandemic.

Secondary variables were collected and compared between groups. There were no significant differences in discharge location, with 80.2% and 73.2% of patients discharged to a dedicated rehabilitation facility for Pre-COVID and During-COVID, respectively ($p=0.333$) (Table 2). There were no significant differences in postoperative hospital deaths ($p=0.493$) (Table 2). Additionally, there were no differences in all-cause 30-, 90-day, and overall readmission and reoperation rates, although overall reoperation rates did have near significance with a reduction in rate during the pandemic (Pre-COVID 6.1% vs During-COVID 2.0%; $p=0.052$) (Table 3). There were no significant differences in 30-, 90-day, and overall mortality rates (Table 3) and postoperative complications (Table 3) between cohorts.

There were no significant differences between gender, BMI, or race between the groups (Tables 1 and 2). There was a significant difference between the age distribution of the patients in each cohort, with no patients in During-COVID less than the age of 50 years. There was an overall trend toward older age during the pandemic. There was also a significant difference in smoking status between the groups with lower rates of 'Never' and 'Current' smokers and higher rates of 'Former' smokers in During-COVID. Logistic regression was performed to detect the effect of

Table 1 Demographics

Demograpics	Group Pre-COVID ($n=263$) Patient n (%)	Group during-COVID ($n=153$) Patient n (%)	P-value
Gender			
Male	104 (39.5)	48 (31.4)	0.95
Female	159 (60.5)	105 (68.6)	
Race			
Caucasian	205 (77.9)	124 (81)	0.747
Hispanic	15 (5.7)	12 (7.8)	
African-American	25 (9.5)	10 (6.5)	
Asian	5 (1.9)	2 (1.3)	
Native-American	2 (0.8)	1 (0.7)	
Unknown	11 (4.2)	4 (2.6)	
Age in years			
< 50	25 (9.5)	0 (0.0)	< 0.001
50–74	59 (22.4)	44 (28.8)	
> 74	179 (68.1)	109 (71.2)	
Smoking Status			
Never	125 (47.5)	61 (39.9)	0.044
Current	42 (16.0)	16 (10.5)	
Former	65 (24.7)	47 (30.7)	
Unknown	31 (11.8)	29 (19.)	
Body mass index	24.9 (5.6)	25.9 (6.9)	0.113
	Average kg/m^2 (SD)	Average kg/m^2 (SD)	P-value
Body mass index	24.9 (5.6)	25.9 (6.9)	0.113

Table 2 Time to surgery and discharge location

Distribution of time to surgery	Group pre-COVID ($n=263$)	Group during-COVID ($n=153$)	P-value
Minimum (h)	3.0	2.0	0.256
Maximum (h)	131.1	141.0	
25th percentile (h)	17.0	17.0	
Median (h)	22.0	23.0	
75th percentile (h)	28.0	32.0	
Discharge location	Patient n (%)	Patient n (%)	P-value
Home	48 (18.3)	36 (23.5)	0.333
Rehabilitation facility	211 (80.2)	112 (73.2)	
Hospital death	2 (0.8)	3 (2.0)	
Hospice	2 (0.8)	2 (1.3)	

independent demographic variables (Age, BMI, Gender, Race, Smoking Status, Surgery Prior to COVID, Surgery During COVID) on primary and secondary outcome dependent variables including (1) TtS, (2) Mortality, (3) Readmission, and (4) Reoperation. Smoking status did not have an effect on mortality or complication rates. Only age less than 75 (OR 4.65; CI 1.30–16.70; $p=0.018$) had an independent effect on overall mortality and male gender (OR 2.10; CI 1.13–3.86; $p=0.017$) had an effect on overall readmission. (Table 3).

Table 3 Readmission, reoperation, mortality rates and post-operative complications

	Group pre-COVID ($n=263$) Patient n (%)	Group during-COVID ($n=153$) Patient n (%)	P-value
Readmission, reoperation, and mortality rates			
30-day Readmission (%)	36 (13.7)	19 (12.4)	0.712
90-day Readmission (%)	35 (13.3)	12 (7.8)	0.090
Overall readmission (%)	**61 (23.2)**	**26 (17.0)**	**0.134**
30-day Reoperation (%)	12 (4.6)	2 (1.3)	0.076
90-day Reoperation (%)	9 (3.4)	1 (0.7)	0.100
Overall reoperation (%)	**21 (7.1)**	**3 (2.0)**	**0.052**
30-day Mortality (%)	19 (7.2)	5 (3.3)	0.095
90-day Mortality (%)	5 (1.9)	6 (3.9)	0.223
Overall mortality (%)	**24 (9.1)**	**11 (7.2)**	**0.493**
Post-operative complications			
Neurologic complications (%)	6 (2.3)	3 (2.0)	1.000
Pulmonary embolism (%)	3 (1.1)	2 (1.3)	1.000
Pneumonia (%)	6 (2.3)	3 (2.0)	1.000
Deep vein thrombosis (%)	5 (1.9)	6 (3.9)	0.223
Acute kidney injury (%)	2 (0.8)	0 (0.0)	0.534
Wound complication (%)	12 (4.6)	6 (3.9)	0.757

Bold indicates overall rates followed by the broken down 30-day and 90 day rates above it

Discussion

The COVID-19 pandemic presented new challenges as hospitals adopted new protocols and reallocated both human and physical resources. Our institution has a multidisciplinary approach for HFx that aims to optimize a patient for surgery within 24–36 h of admission. Despite the challenges presented by the pandemic, patients presenting to our institution experienced a median TtS of 22 h prior to COVID-19 and 23 h during the pandemic, both of which are consistent with the TtS suggested in current literature to minimize complication rates and optimize postoperative outcomes [11, 12]. The consistency of our primary outcome measure prior to and during the pandemic can be attributed to two major factors. First, our institution maintained a smaller, but dedicated medical consulting service that provided perioperative medical comanagement during the pandemic. Our institution recognized the importance of maintaining a service such that all-comers to the hospital with "urgent" medical and surgical conditions beyond COVID-19 could be managed appropriately. The benefit of maintaining a medical service is highlighted by our results, which demonstrate no significant change in the course of care or outcomes for hip fracture patients. Second, our institution had less competition for operating room (OR) availability. While there was a reduction in OR staff, there was also less competition for block time. Elective surgeries were canceled, and only "urgent" cases were permitted across all surgical specialties. Thus, there were more "open" operating rooms. It was this unique combination of pre-established, efficient perioperative workflow with the decreased caseload crowding in the OR that resulted in our institution to have no change in hip fracture management and subsequent outcomes.

Previous studies have reported 30-day readmission rates for HFx between 10.7% to 11.9% and 90-day readmission rates around 19.7% [20–22]. Our secondary outcome results are in line with previous literature as 30- and 90-day readmission rates prior to the pandemic were 13.7% and 13.3%, respectively [20–22]. During the pandemic, our 30- and 90-day readmission rates were 12.4% and 7.8%, respectively. Overall all-cause reoperation rates did not differ statistically, but did have near significance with a reduction in reoperation rates during the pandemic. While the absolute numbers of reoperation were low between cohorts, the relatively lower rate during the pandemic could again be attributed to the overall decrease in surgical volume, both elective and urgent. As case volumes decreased, it is possible that there was less pressure to complete cases quickly, perhaps contributing to the marginally improved outcomes.

Limitations of this study include its retrospective design. However, this was necessary given the nature of a pandemic. We compared patients in the pandemic cohort to patients just prior to the pandemic. This was done to ensure that the pandemic cohort would be compared to those who were treated with the most recent standard of practice at our institution. The continuity of our two cohorts also provided insight into how our institution responded in the midst of a major transition in how healthcare was practiced. Second, this study did not evaluate the effect of COVID-positive status on outcomes. Patients presented with a wide range of symptoms and health conditions. While a COVID-infection places a patient at higher risk for complications, especially given the potentially devastating pulmonary effects of the virus, this study's focus was on overall outcomes of a major hospital system's response to the pandemic [24]. Further, COVID tests have had varying degrees of reported sensitivities, and the results may be affected by multiple factors including specimen amount and the time the specimen was collected in relation to exposure or onset of symptoms [25]. Further long-term investigation into morbidity and mortality of HFx and concomitant COVID infection will provide valuable information as the virus and its variants continue to trouble hospital systems.

This study also has many strengths. We report data with 90-day follow-up which improves the overall generalizability of the study. By analyzing the two cohorts in continuity, we

were able to illustrate how a major health system responded to the stresses of treating COVID-19 patients while also maintaining standards of care for other health care conditions. HFx have been extensively studied in literature, so the results of this study can be compared to already existing data.

Several other studies have delineated challenges in treatment of traumatic hip fractures during the pandemic resulting in suboptimal outcomes. Egol et al. reported significantly elevated mortality rate following hip fracture fixation in the COVID-19 positive patient group compared to COVID-19 negative patients at their New York City public hospital [16]. Higher risk of mortality post-treatment for hip fracture were consistent in notable studies conducted in China, Italy, and Spain, reinforcing COVID-19 as a universal barrier to optimal outcomes [17]. Additionally, at the forefront of risk to contract this airborne/droplet-borne virus were the surgeons exposed on the wards and in the OR [16]. During a 1-month period in Wuhan, China, 26 orthopedic surgeons across 8 different hospitals tested positive for COVID-19, severely decreasing the workforce for hip fracture surgical intervention, ultimately limiting access for patients in need of treatment [16]. Our DC group had only a few COVID-19 positive patients, therefore the increased risk in mortality did not play a significant role in the outcomes, and the risk of transmission to our surgical teams in the orthopedic department was diminished compared to global hospital systems.

There was a trend toward higher age in the COVID-19 cohort, with 71.2% of patients over the age of 74 years and 100% of patients being over the age of 50 years. Aging is one of the many risk factors associated with developing chronic medical conditions and comorbidities, and higher age and increased comorbidities placed patients at higher risk for the most devastating complications including death [23]. The focus of this study was not on the effect of a COVID-positive diagnosis on overall outcomes. However, the trend toward older age in the COVID cohort reinforces the importance of following safety standards to mitigate risk of patients complications. Certain units in the hospital were dedicated to patients who were "COVID-positive." Efforts were made to separate these patients from those who tested negative. There were dedicated COVID-OR and staff for those patients with positive results. Analysis of specific comorbidities and their relationship to patient outcomes was beyond the scope of this study. However, our results demonstrate that, despite the challenges presented by the pandemic, overall outcomes for all HFx were not drastically affected.

Upon more in depth investigation into how intragroup demographic variability affected post-surgical outcomes, it was shown that patients who were below the age of 75 had a 4.65 increased odds for overall mortality and patients who were male had a 2.10 increased odds for overall readmissions. In their multicenter database study, Checketts et al. reported that male patients were more likely to be readmitted than female patients after HFx [20]. The same study by Checketts et al. reported a possible ceiling effect of age on readmission rates, with older patients having a higher risk prior to 75 years, whereas after 75 years the association became stable [20]. While our data was significant for association between age and mortality, it is possible that a similar principle could be applied. Age is generally associated with higher risk of complications, so the specific reason why patients under the age of 75 had increased odds for overall mortality in our cohort is unclear [20]. This could indicate potential factors that could be affecting post-surgical outcome measures that are beyond the scope of this particular study, but may warrant further investigation in future.

Conclusion

Despite the challenges presented to our institution in the setting of COVID-19, overall patient care was not compromised. HFx represent a fraction of overall hospital admissions. As COVID-19 and its variants continue to impact workflow within hospitals worldwide, a conscientious effort must be made to avoid compromising other aspects of patient care. Although TtS and clearance for HFx remains a challenge for other institutions, both before and during the pandemic, our institution had a perioperative protocol already in place for traumatic HFx involving coordinated multidisciplinary care that was optimized by the preferential operating time slots, which resulted in no significant deficit to the department's workflow or patient outcomes. Providers should strive to continue following current guidelines and ensure timely intervention for HFx while maintaining the safety of healthcare staff and patients. Our group offers our own experiences, protocols, and reasonings as a hospital system model which successfully bypassed the COVID-19 obstacles to care for traumatic hip fracture patients.

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Declarations

Conflicts of interest None of the authors have conflicts of interest to declare. The authors did not receive support from any organization for the submitted work.

Ethical approval This study was approved by the authors' institution's ethics committee and was performed in accordance with ethical standards in the Declaration of Helsinki.

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