



A Level 1 Trauma Center's response to the COVID-19 pandemic in New York City: a qualitative and quantitative story

Nina D. Fisher¹ · Andrew S. Bi¹ · Vinay Aggarwal^{1,2} · Philipp Leucht^{1,2} · Nirmal C. Tejwani^{1,2} · Toni M. McLaurin^{1,2}

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Abstract

Background The purpose of this study is to describe a Level 1 Trauma Center's orthopedic response to the COVID-19 pandemic, and to compare outcomes of acute fracture patients pre-COVID versus during the COVID-19 pandemic.

Methods All inpatient fracture cases performed over a 5-month period were identified and retrospective chart review performed. Patients were divided into pre- and COVID-era groups based on when surgery was performed relative to March 16, 2020 (the date elective operations were ceased), and groups were statistically compared. Patients with a COVID test result were further sub-divided into COVID negative and positive groups, and statistically compared. Statistical analysis was performed using independent *t*-test for continuous variables and chi-square analysis for categorical variables.

Results One hundred and nineteen patients were identified, 38% females with average age of 58 years. Average length of stay was 7 days with average time from injury to surgery of 3 days and average time from admission to surgery of 1.3 days. Overall in-hospital complication rate was 29.4%, and 30-day mortality and readmission rates were 2.5% and 5%, respectively. Sixty-nine patients comprised the pre-COVID group, and 50 in the COVID-era group. There was no significant difference with respect to length of stay, time from injury to surgery, time from admission to surgery, need for post-operative ICU stay, in-hospital complication rate, 30-day mortality rate and 30-day readmission rate. Thirty-four patients had COVID testing, with 24 negative and 10 positive. COVID-positive patients had longer time from injury to surgery (8.5 days vs. 2 days, $p=0.003$) and longer time from admission to surgery (2.7 days vs. 1.2 days, $p=0.034$). While more COVID-positive patients required ICU admission post-operatively (60% vs. 21%, $p=0.036$), there was no difference in overall complication rate.

Conclusions Orthopedic care of acute fracture patients was not affected by a global pandemic. The response of our Level 1 Trauma Center's orthopedic department can guide other hospitals if and when new surges in COVID cases arise, in order to prevent compromising appropriate orthopedic care.

Level of evidence Prognostic III.

Keywords Orthopedic trauma · COVID-19 · Fracture · Outcomes · Complications

Introduction

The first case of COVID-19 presented in New York City (NYC) on March 1, 2020 [1] and as cases spread exponentially, NYC quickly became one of the global epicenters of the pandemic. As of May 2, 2020, a total of 13,831 laboratory-confirmed COVID-19-associated deaths, and 5048

probable COVID-19-associated deaths were recorded in NYC [2]. As of June 10, 2020, there have been 190,856 confirmed cases of COVID-19 across the five boroughs of NYC, and 30,500 deaths, although 67,808 successful recoveries should also be emphasized [3]. Multiple hospitals and medical centers have qualitatively described their systems' responses to this pandemic. However, none have provided quantitative data of their efforts [4–8].

A hospital system which has endured a disproportionate brunt of the pandemic's challenges is NYC Health + Hospitals (NYC H + H). The largest public health care system in the US (US) comprised of 11 acute care hospitals, 5 acute care/long term care facilities, and numerous outpatient facilities across all five boroughs, NYC H + H serves

✉ Nina D. Fisher
Nina.Fisher@nyulangone.org

¹ Department of Orthopedic Surgery, NYU Langone Health, NYU Langone Orthopedic Hospital, New York, NY, USA

² Department of Orthopedic Surgery, Health and Hospitals, Bellevue, New York, NY, USA

an incredibly wide range of patients, including some of the most vulnerable [9]. In early days of the pandemic, horrific scenes were reported from several of the acute care hospitals, from overwhelmed emergency departments (ED) to makeshift morgues [10–12].

The flagship hospital of NYC H + H, and the oldest public hospital in the US resides in the center of Manhattan [13]. Arguably one of the most-prepared hospitals, given past experiences with the AIDS epidemic and Ebola virus, our hospital quickly adjusted to accommodate the overflow from other H + H hospitals, while maintaining care of their own admissions, including orthopedic trauma cases. In comparison, several H + H hospitals became overwhelmed with COVID patients, and, lacking adequate operating room, ICU or anesthesia resources and/or personnel to perform non-emergent cases, began transferring all urgent operative orthopedic cases to our hospital.

In the midst of the pandemic, our orthopedic surgery department continued to provide timely care to patients who sustained traumatic orthopedic injuries necessitating urgent or emergent surgery. Considering the unprecedented nature of this clinical healthcare situation, it is prudent to review the patients treated during this time period to determine if their care, including time to surgery and hospital complications, were affected by the COVID-19 pandemic. The primary purpose of this study is to compare time from injury to surgery and admission as well as hospital complications between inpatients treated pre- and during the COVID pandemic. Secondary aims are to provide a qualitative report on a large, urban public hospital's response to COVID-19.

Methods

Qualitative description of a Level 1 Trauma Center's response to COVID-19

Our institution underwent a rapid change to accommodate the sudden and monumental influx of COVID-19 patients. One of the largest challenges was providing enough ICU and ventilator beds and the entire ICU floor was converted to a respiratory COVID ICU ward, with non-COVID ICU level patients moved to the post-anesthesia care unit (PACU). Additionally, the emergency ward (EW), which functions as a high-acuity monitored ward for traumas and Emergency Department (ED) visits, was converted to a respiratory COVID ICU ward. All but four of 18 operating rooms (ORs) were converted into ICU beds with negative pressure rooms (Fig. 1). As admissions and intubations rapidly climbed, endoscopy suites and several hospital floor units were also converted into COVID-19 respiratory units and ICUs. Despite these efforts, over ten ICU rooms had to



Fig. 1 One of Bellevue Hospital's operating rooms converted to a negative pressure COVID-19 ICU room

be converted to double patient rooms to accommodate the influx.

At its peak, our hospital was accepting approximately 40 transfers a day from other H + H hospitals, with 75% floor status patients and 25% requiring ICU level of care. Rapid responses and respiratory codes were called at extremely high rates, averaging 20–30 per day with a record high of 37 on April 15 2020. In response, there was a massive increase in provider manpower, with volunteer efforts from non-medical specialties providing both residents and attendings to help the Internal Medicine department expand to a high of 22 teams from their usual 9 teams. In addition, the hospital's affiliated medical school made the unprecedented decision to offer their senior medical students the option to graduate early and work in either the wards or ED, and 52 students joined the ranks of COVID health care providers [14].

In order to limit exposure to patients, our institution's Ambulatory Care Center drastically limited the number of in person visits, and within orthopedic clinics, only necessary post-operative or post-fracture patients were seen in person. The vast majority of patients across specialties was contacted by telephone and informed to delay their visit or converted to telemedicine visits when possible. An ambulatory testing center was set up outside of the hospital's main entrance to allow for patient and employee testing to avoid overwhelming the ED. The arrival of the USNS Comfort, a naval Mercy-class hospital ship, field hospitals set up in Central Park and in the Javitz Convention Center, and a newly opened long-term acute care facility on Roosevelt Island all helped to offload the hospital's burden, as did a large influx of nurses, respiratory therapists and medics from traveling nurse agencies and multiple branches of the military.

Our orthopedic department responded rapidly and efficiently as well. All elective surgical cases were suspended

as of March 16, 2020, the day after NYC leadership's announcement. Our orthopedic team continued to see orthopedic consults and traumas and accept all operative transfers from other H + H hospitals that no longer had the resources to provide surgical care. This placed a definite strain on the orthopedic team, especially as the team had been divided in half; both to respect social distancing and to prevent the potential problem of the entire team becoming ill. As tests became available, all admissions and operative cases underwent COVID testing, with negative post-operative patients recovering in the limited, non-ICU space in the PACU, while positive patients recovered in the OR then were transported directly back to their isolation rooms.

In addition, our orthopedic team formed the hospital's only "Prone Team", which consisted at its peak of two teams, each with four orthopedic attendings and/or residents and two airway members from anesthesia per team. Every day for 10 weeks at 10 am the Prone Team would flip prone patients supine, and at 3 pm flip supine patients to prone where they would stay for the next 16 h (Fig. 2). Patients were deemed prone candidates by the medical ICU teams. A standardized methodology with a "pre-procedural" time out was developed, with patients prone in the swimmer's position with one arm extended overhead, one leg flexed at the hip and knee and the head rotated to one side, all to avoid pressure ulcers and neuropraxias. After 10 weeks, prone duties were taught and transferred to nursing and military medical provider volunteers.

Quantitative analysis

The operating room log at our hospital between January 1, 2020 and May 15, 2020 was reviewed to identify all inpatient fracture cases. As the operating room log was used



Fig. 2 Members of the Bellevue Orthopedic Surgery Department prior to proning a ventilated COVID-19 patient

to identify patients for this study, non-operative patients were thus excluded from analysis. Once all inpatient fracture cases were identified, retrospective chart review was performed to obtain demographic information, medical comorbidities, mechanism of injury, additional injuries, length of stay, in-hospital complications, and 30-day mortality and readmission rates. Time from injury and from admission to surgery were calculated.

Patients were then divided into pre-COVID and COVID groups based on whether surgery was performed before or after March 16, 2020, which is the day the hospital NYC H + H suspended all non-essential surgeries in order to accommodate COVID patient influx. Patients with a COVID test result were further sub-divided into COVID negative (COVID-) and positive (COVID+) groups. COVID testing involved polymerase chain reaction (PCR) testing from a nasopharyngeal swab.

All statistical analysis was performed using SPSS Version 21 (SPSS, Inc., Chicago, IL, USA). Statistical analysis was performed using independent t-test for continuous variables and chi-square analysis for categorical variables. Descriptive statistics are reported as means for continuous variables and percentages for categorical variables.

Results

One hundred and nineteen patients underwent inpatient operative fixation for an acute fracture between January 1, 2020 and May 15, 2020. The average age was 58.27 ± 21.9 years, with 37.8% females. With respect to race/ethnicity, the group was 28.6% (34) Caucasian, 14.3% (17) African-American, 15.1% (18) Hispanic, 10.9% (13) Asian, and 31.1% (37) Other/Unknown. The average body-mass index (BMI) was 24.98 ± 4.7 kg/m² and the average Charlson Co-morbidity Index (CCI) was 2.17 ± 2.2 . With respect to mechanism of injury, 57.1% were low-energy, 42.9% were high-energy, and 24.4% had additional injuries. Twenty-seven patients (22.7%) were transfers from outside hospitals. The average length of stay was 7.04 ± 8.2 days, with an average time from injury to surgery of 3.21 ± 5.2 days and an average time from admission to surgery of 1.31 ± 1.6 days. Forty patients (33.6%) required ICU level of care post-operatively. The overall in-hospital complication rate was 29.4%, and the 30-day mortality and readmission rates were 2.5% and 5%, respectively.

There were 69 patients in the pre-COVID group, and 50 patients in the COVID group (Table 1). There was no statistically significant difference between the groups with respect to age, gender, BMI, CCI, or mechanism of injury. Furthermore, there was no difference in length of stay, time from injury to surgery, time from admission to surgery, need for ICU stay in post-operative period, in-hospital complication

Table 1 Demographics, Hospital Admission Factors and Complication Rates of Patients Admitted Pre- and During- the COVID-19 pandemic in NYC

	Pre-COVID (N=69)	COVID (N=50)	Sig.
Age	58.20±20.4	58.36±24.0	0.969
Female gender	37.7% (26)	38.0% (19)	0.561
BMI	25.13±4.7	24.76±4.7	0.685
CCI	2.12±2.1	2.24±2.44	0.764
Low mechanism of injury	59.4% (41)	54.0% (27)	0.343
Additional injuries	24.6% (17)	24.0% (12)	0.556
Transfer from outside hospital	11.6% (8)	38.0% (19)	0.001
ICU admission post-Op	34.8% (24)	32.0% (16)	0.453
LOS (days)	7.52±9.4	6.34±6.1	0.450
Time from injury to surgery	3.37±5.3	3.00±5.2	0.710
Time from admission to surgery	1.33±1.5	1.28±1.7	0.855
In-hospital complications	30.4% (21)	28.0% (14)	0.468
Number of complications	0.54±1.1	0.50±1.0	0.845
30-day mortality	1.4% (1)	4.0% (2)	0.380
30-day readmission	4.3% (3)	6.0% (3)	0.498

Statistically significant p-values are bolded

rate, 30-day mortality rate and 30-day readmission rate. However, a greater proportion of the patients in the COVID group was transfers from outside hospitals (38% vs. 11.6%, $p=0.001$).

COVID testing was performed in 34 patients, with 24 testing negative and 10 testing positive (Table 2). There was no significant difference with respect to age, BMI, CCI, or length of stay between COVID+ and COVID- patients. However, COVID+ patients were more often female (60% vs. 16.7%, $p=0.019$), more frequently had a low-energy mechanism of injury (80% vs. 42%, $p=0.046$),

Table 2 Demographics, Hospital Admission Factors and Complication Rates of COVID-19 Negative versus COVID-19 Positive Patients

	COVID negative (N=24)	COVID positive (N=10)	Sig.
Age	55.67±23.2	68.70±22.8	0.144
Female gender	16.7% (4)	60.0% (6)	0.019
BMI	24.07±4.1	25.95±6.4	0.335
CCI	2.13±2.8	3.30±2.1	0.243
Low-energy mechanism of injury	41.7% (10)	80.0% (8)	0.046
Additional injuries	33.3% (8)	20.0% (2)	0.367
LOS	7.91±7.4	9.00±5.2	0.690
Time from injury to surgery	2.08±3.7	8.50±7.8	0.003
Time from admission to surgery	1.21±0.7	2.70±3.16	0.034
ICU admission post-op	20.8% (5)	60.0% (6)	0.036
In-hospital complications	29.2% (7)	50.0% (5)	0.221
Number of complications	0.46±0.7	1.20±1.5	0.056
30-day mortality	4.2% (1)	20.0% (2)	0.201
30-day readmission	8.3% (2)	20.0% (2)	0.334

Statistically significant p-values are bolded

and had longer time from injury to surgery (8.5 days vs. 2 days, $p=0.003$) as well as longer time from admission to surgery (2.7 days vs. 1.2 days, $p=0.034$). Post-operative venous thromboembolism and anemia trended toward significantly higher rates in COVID+ patients (20%, $p=0.080$; 50%, $p=0.060$). While more COVID+ patients required an ICU stay post-operatively (60% vs. 21%, $p=0.036$), there was no difference in overall complication rates (Table 3) or 30-day mortality rates (Table 2) between COVID+ and COVID- patients.

Discussion

Multiple hospitals and medical centers have described their systems' experiences and response to the COVID-19 pandemic, which included the elimination of elective procedures, implementation of telemedicine and remote health visits, limiting clinic visits and hospital visitors, and repurposing orthopedic residents and attendings to assist with the

Table 3 Complications in COVID positive versus COVID negative patients

	COVID negative (N=24)	COVID positive (N=10)	Sig.
Cardiac arrest	4.2% (1)	10% (1)	0.508
Post-operative anemia	16.7% (4)	50.0% (5)	0.060
Acute respiratory failure	4.2% (1)	10.0% (1)	0.508
DVT/PE	0.0% (0)	20.0% (2)	0.080
Pneumonia	4.2% (1)	20.0% (2)	0.201
Sepsis	4.2% (1)	0.0% (0)	0.706
Myocardial infarction	0.0% (0)	10.0% (1)	0.294
Urinary tract infection	4.2% (1)	0.0% (0)	0.706

medical care of COVID-positive patients [4–8]. However, none to date have provided a quantitative analysis of surgical management of orthopedic trauma patients. This study also serves to provide the largest cohort of orthopedic trauma patients with COVID positive tests in the literature thus far.

This analysis demonstrates no difference in time from injury of admission to time of surgery in orthopedic trauma patients prior to the March 16, 2020 cancelation of elective cases compared to afterward. This was in spite of a significant increase in the percentage of patients transferred from outside hospitals over the same time period. This is an important finding in light of prior literature reporting negative impacts on morbidity and mortality in both medical and surgical fields related to delays in care secondary to transfers between facilities [15–17]. In addition, there were no significant differences in rates of ICU admission post-operatively, or hospital length of stay in pre-COVID versus COVID-era groups. Overall in-hospital complication rates were 29.4%, with the majority of complications consisting of post-operative anemia requiring a blood transfusion [18]. There were no significant differences in complication rates when comparing patients pre-COVID and during COVID, including no difference in rates of venous thromboembolism (VTE) or respiratory distress.

While there was no difference in time to surgery in patients pre-COVID and during COVID at our institution, when COVID status was examined, COVID+ patients had significantly longer delays from time of injury and admission to surgery. Although there is no prior literature to compare these results to, the difference in time from injury to surgery (8.5 days vs. 2.1 days) can likely be explained by patients' fears of presenting to the ED despite their injuries given the coronavirus pandemic. The difference in time from hospital admission to surgery was smaller (2.7 days vs. 1.2 days), and can be attributed to both the need for prolonged medical optimization given COVID+ status, as well as increased efforts at non-operative management in COVID+ patients given the unknown perioperative surgical risk factors of coronavirus at that time [19, 20].

COVID+ patients were more likely to require an ICU admission post-operatively than COVID- patients, and although there were no significant differences in complication rates, COVID+ patients trended toward increased complication rates and 30-day readmission and mortality rates. In particular, the rate of post-operative anemia requiring a transfusion (50% vs. 16.7%) and rate of VTE (20% vs. 0%) were increased in COVID+ patients although neither were statistically significant. These results could signify abnormal hematologic conditions that have been reported in COVID+ patients, and may likely have reached significance with a larger orthopedic trauma patient cohort [21–23].

There are several limitations to our study. First, this is a single-center, retrospective cohort study with a small sample

size. Second, and perhaps more importantly, there is no prior literature with quantitative analysis examining the impact of COVID-19 in orthopedic trauma to compare our results to and verify our findings. Only one small study of 10 patients looked at the effect of COVID-19 in acute fracture patients, and recommended judicious use of surgical management in COVID+ fracture patients [24]. However, no studies to date have investigated how, if at all, the COVID-19 pandemic affected the care of acute fracture patients regardless of COVID status. Third, we were unable to account for all orthopedic trauma patients that were evaluated and treated at our hospital, as several were managed non-operatively secondary to mortality risk and being too unstable to undergo surgery. On several occasions, patients required further medical optimization, but then decompensated, were transferred to ICU level care and died prior to orthopedic intervention, and thus were not included in our study given our methodology.

Conclusion

Despite being in the epicenter of a global pandemic, our large, urban public hospital and Level 1 Trauma Center in the New York metro area was able to continue to provide timely and high-quality orthopedic care to acute fracture patients, with no difference in time to surgery or complication rate compared to the pre-COVID era. It is our hope that the qualitative description of the mobilization of the entirety of New York City's flagship public hospital and its orthopedic department, as well as the quantitative data within this study, can be used to guide other hospitals if and when new surges in COVID cases arise, in order to prevent compromising appropriate orthopedic care. These institution-specific responses and results should be taken into consideration within the broader orthopedic community's recommendation to formulate improved action plans going forward in treating orthopedic trauma in the new COVID era [25, 26].

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Compliance with ethical standards

Conflict of interest The authors have no relevant financial or non-financial interests to disclose. The authors have no conflicts of interest to declare that are relevant to the content of this article. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript. The authors have no financial or proprietary interests in any material discussed in this article.

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