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Outcomes of orthopaedic trauma surgery in COVID-19 positive patients

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Abstract

Objectives: To investigate outcomes for operative orthopaedic trauma in patients who tested positive for coronavirus disease 2019 (COVID-19) during the height of the COVID-19 pandemic in New York.

Design: Retrospective case series.

Setting: Urban Level-1 academic trauma center.

Patients/participants: Thirteen patients diagnosed with COVID-19 who underwent surgical management for orthopaedic trauma between January 21, 2020 and May 11, 2020.

Intervention: Does not apply to this study.

Main outcome measurements: Complications including death, coma lasting more than 24 hours, prolonged mechanical ventilation, unplanned intubation, blood transfusion, postoperative pneumonia, cerebrovascular event, thromboembolic event, myocardial infarction, urinary tract infection, acute renal failure, septic shock, return to the operating room, wound dehiscence, surgical site infection, graft/prosthesis/flap failure, and peripheral nerve injury.

Results: Two (18%) patients had symptoms of COVID-19 (cough, shortness of breath, fevers, chills, nausea/vomiting, diarrhea, abdominal cramps/pains) on admission. Average length of stay (standard deviation) was 6.6 (4.31) days. Average time to follow up was 29 (10.77) days. Three (27%) patients developed pneumonia postoperatively and 1 (9%) underwent unplanned intubation. One (9%) patient was intubated for greater than 48 hours. Two (18%) patients developed postoperative deep venous thromboembolism. Three (27%) patients developed acute renal failure postoperatively. Six (55%) patients underwent blood transfusion intraoperatively or postoperatively. Two (18%) patients died postoperatively.

Conclusion: In this small series surgical management in Coronavirus-19 positive patients with skeletal injuries was successfully accomplished with patient anticoagulation, hematologic, and pulmonary status in mind. Therapeutic anticoagulation and patient hematologic status were optimized prior to the operating room to minimize development of venous thromboembolism and avoid blood transfusion.

Level of evidence: Level IV prognostic

Keywords: COVID-19, infection, operative trauma, orthopaedic trauma, pandemic, venous thromboembolism

1. Introduction

The novel SARS-CoV-2 betacoronavirus was found to be the cause of pneumonia of unknown origin devastating patients in Wuhan, the People's Republic of China in December 2019. The disease was subsequently declared a pandemic on March 11, 2020 by the World Health Organization.[1] There were approximately 118,000 cases and 4291 deaths worldwide at that time. This is the first pandemic known to be due to a new

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coronavirus.[2] The first confirmed case in the United States was reported on January 21, 2020. As of August 9, 2020, there are an estimated 4,920,369 cases and 160,220 total deaths in the United States alone.[3]

Since 2000 there have been 2 other events with crossover of animal betacoronaviruses to humans leading to disease.[4] The first in 2002 to 2003 occurred with severe acute respiratory syndrome coronavirus (SARS). This was due to a crossover of a coronavirus in bats to humans via a palm civet cat intermediate in Guangdong province of China. The second occurred with Middle East Respiratory syndrome (MERS-CoV). MERS-CoV was also the result of crossover of a virus originating from bats. It was transmitted to humans via a dromedary camel intermediate in Saudi Arabia.

Similar to MERS-CoV and SARS, coronavirus disease 2019 (COVID-19) has its origins in bats.[4] The current suspected intermediates for transmission of COVID-19 to humans are pangolins and snakes. It is thought that the virus is transmitted through large droplets generated from coughing and sneezing in symptomatic or asymptomatic individuals with the virus. The virus is capable of survival on surfaces for days and can cause infection if an individual were to touch that surface and then their nose, eyes, or mouth. Individuals are infectious when they are symptomatic as well as in recovery. Thus, good hygiene and sterilization methods are essential to prevent transmission, especially when the virus can be destroyed with common disinfectants.

Despite state-wide stay-at-home orders, orthopaedic trauma continued to present to our institution during the pandemic. In addition, our health system saw an almost 100% increase in COVID-19 positive patients and persons under investigation from late March to mid-April 2020.

COVID-19 positive patients may suffer from a plethora of complications beyond respiratory compromise. This includes secondary pulmonary infection, extreme elevations in inflammatory cytokines, acute kidney injury, D-dimer elevation, hypercoagulability, and myocardial injury.[5] The current dearth of data on SARS-CoV-2 infection and its effect on operative trauma outcomes underscore the need for further investigations.

The purpose of this study was to investigate outcomes for operative orthopaedic trauma cases in patients who tested positive for COVID-19 at a Level 1 academic trauma center in New York.

2. Material and methods

Approval was obtained from the Stony Brook University institutional review board (IRB2020-00261, Joshua Namm, MD) with waiver of informed consent. An electronic medical record search from January 21, 2020 to May 11, 2020 was performed to identify patients 18 years or older who underwent operative management for orthopaedic trauma and tested positive for COVID-19 using reverse transcriptase polymerase chain reaction (RT-PCR) testing through an in-house laboratory. The date of confirmed COVID-19 diagnosis was prior to or after the date of surgery as our study collected data during the height of the COVID-19 pandemic in New York. At that time issues with testing availability, test sensitivity, and test specificity frequently delayed COVID-19 diagnosis of our patients. Thirteen subjects were found to meet inclusion criteria. Subjects' medical records, laboratory data, operative reports, and follow-up data were reviewed. Patient data including race, gender, body mass index, health status (history of diabetes, steroid use, chronic obstructive pulmonary disease, other pulmonary comorbidities, kidney disease, dialysis use), tobacco and alcohol use, substance abuse, functional status using categories from American College of Surgeons National Surgical Quality Improvement Program, and American Society of Anesthesiologists classification were coded and recorded.

Additionally, patient postoperative and intraoperative complications including death, coma lasting more than 24 hours, on ventilator more than 48 hours, unplanned intubation, intraoperative or postoperative blood transfusions, postoperative pneumonia, stroke/cerebrovascular accident, thromboembolic event (deep venous thrombosis or pulmonary embolism), cardiac arrest, myocardial infarction, urinary tract infection, acute renal failure, sepsis, septic shock, return to the operating room, wound dehiscence, deep surgical site infection, organ/space infection, graft/prosthesis/flap failure, and peripheral nerve injury were recorded.

Length of stay, fracture type, injury mechanism, Injury Severity Score (ISS), Orthopaedic Trauma Association (OTA) classification, Gustillo-Anderson classification for open fractures, type of definitive fixation, and type of intraoperative anesthesia administered were also recorded.

Eleven total patients were included in this study. Our study population comprised 55% males (6/11) and 45% females (5/11) with an average (SD) age of 64.30 (20.03). There were 7 Caucasian patients (64%), 0 Black (0%), 1 Hispanic (9%), 1 Asian (9%), and 2 from another race (18%) not specified otherwise. Patient comorbidities and functional status are presented in Table 1. In terms of function, 7 (64%) patients were described as independent while 4 (36%) patients were dependent. Diabetes was found in 27% of our study population. There was 1 patient (9%) who reported current or previous use of steroids. Six patients (55%) were described as current or former smokers, 3 patients (27%) were found to have a history of alcohol abuse, and 0 patients were current or former intravenous drug users. In terms of medical comorbidities, 3 (27%) patients had a history of chronic obstructive pulmonary disease, 6 (55%) patients had a history of hypertension, 3 (27%) patients had a history of chronic kidney disease, and 1 (9%) patient was on dialysis.

Information on fracture mechanism, type, Injury Severity Score, OTA score, American Society of Anesthesiologists class, anesthesia used, and method of fixation is presented in Table 2. There were no open fractures in our study population. Five (45%) patients sustained hip fractures. One of these hip fractures

Table 1

Study population comorbidities

Comorbidities	Percentage of study population
BMI	29.1
Diabetes mellitus	27%
Steroid use (current or previous)	9%
Alcohol abuse	27%
Smoking history (current or previous)	55%
COPD	27%
CHF	18%
HTN	55%
CKD	27%
Dialysis	9%
COVID-19 symptoms on admission	18%

BMI = body mass index, CHF = congestive heart failure, CKD = chronic kidney disease, COPD = chronic obstructive pulmonary disease, COVID-19 = coronavirus disease 2019, HTN = hypertension.

Table 2

Injury type, severity, fixation, and anesthetic considerations

Injury severity score	Fracture type	OTA classification	Type of definitive fixation	ASA class	Anesthesia type
10	Trimalleolar ankle	44C1.3	Mini fragment buttress plate, 1/3 tubular plate, lag screw	3E	General
9	Subtrochanteric femur	32A1.1	Cephalomedullary nail	3	General
9	Femoral neck	31B3	Hip hemiarthroplasty	3	General
9	Intertrochanteric femur	4F1A	Hip hemiarthroplasty	4	General
10	Periprosthetic proximal femur	Vancouver B2	Revision hemiarthroplasty	3	General
9	Tibia/fibula	42A2C, 4F2B	Intramedullary nail	2E	Neuraxial
9	Distal femur	33B2.1	Intramedullary nail	2E	General
9	Distal fibula	4F3A	Distal fibula locking plate	3	General
13	N/A	N/A	FDL to PT tendon transfer, side to side transfer of PT tendon to FDL tendon	2	General
10	Intertrochanteric femur, femoral shaft, supracondylar distal femur	31A1, 32A2, 33A2	Cephalomedullary nail	3	General
17	Tibial pilon	43C2	Intramedullary nail with ORIF	4	General

ASA = American Society of Anesthesiologists, FDL = flexor digitorum longus, OTA = orthopaedic trauma association, PT = posterior tibialis.

was a Vancouver B2 periprosthetic fracture, while another involved an intertrochanteric component, a femoral shaft component, and a supracondylar distal femur fracture. The remainder of injuries included 1 pilon fracture, 1 trimalleolar ankle fracture, 1 tibia/fibula fracture, and 1 tendinous injury.

3. Results

Of the 11 patients in this study, 2 (18%) had symptoms of COVID-19 (cough, shortness of breath, fevers, chills, nausea/vomiting, diarrhea, abdominal cramps/pains) on admission. Four patients were formally diagnosed with COVID-19 postoperatively.

Two (18%) patients died postoperatively. One patient died prior to follow-up. Average length of stay was 6.6 (4.31) days. Average time to follow-up was 29 (10.77) days. Two patients were lost to follow-up. Three (27%) patients developed pneumonia postoperatively and 1 (9%) underwent unplanned intubation. One (9%) patient was intubated for greater than 48 hours. Two (18%) patients developed postoperative deep venous thromboembolism. Three (27%) patients developed acute renal failure postoperatively. Six (55%) patients underwent blood transfusion intraoperatively or postoperatively. No patients returned to the operating room, developed superficial or deep surgical site infections, wound dehiscence, organ or space infections, implant failure, stroke or cerebral vascular accident, pulmonary embolism, urinary tract infection, myocardial infarction, or sepsis postoperatively.

Table 3 reports results as a function of age (under 50 vs over 50 years of age) and presence of significant comorbidities. Table 4 compares symptomatic versus asymptomatic COVID-19 patients. For comparison purposes, symptomatic patients are those who developed pneumonia.

4. Discussion

Currently, there are few studies in the orthopaedic trauma literature that have investigated the relationship between SARS-CoV-2, operative outcomes, and fracture management. One recently published retrospective study examined the characteristics of COVID-19 infection and prognosis in fracture patients in China.[6] The authors analyzed data from 10 hospitalized patients with SARS-CoV-2 infection and fracture. They found that 30% died after admission but prior to surgery and 10% of patients died 11 days postoperatively. Moreover, 30% of their patients had negative RT-PCR testing. This was consistent with our data which showed an 18% postoperative mortality. Preoperative mortality was out of scope as the main focus of the present study was to investigate postoperative mortality and outcomes for patients who had undergone surgery for orthopaedic injury and tested positive for COVID-19 pre- or postoperatively. Postoperative COVID-19 diagnosis was acceptable as testing was limited, the validity of certain tests was still unknown, and preoperative COVID-19 testing was not yet mandatory at our institution early in the pandemic. One article published by

Table 3

Complications as a function of age and presence of significant comorbidities

	Mortality	Pneumonia postop	Unplanned intubation	DVT	Ventilator >48 hours	Acute renal failure	Blood transfusions
<50 and no comorbidities	0% (0/1)	0% (0/1)	0% (0/1)	0% (0/1)	0% (0/1)	0% (0/1)	0% (0/1)
<50 and 1 or more comorbidities	0% (0/2)	0% (0/2)	0% (0/2)	50% (1/2)	0% (0/2)	0% (0/2)	0% (0/2)
>50 and no comorbidities	0% (0/1)	0% (0/1)	0% (0/1)	0% (0/1)	0% (0/1)	0% (0/1)	100% (1/1)
>50 and 1 or more comorbidities	29% (2/7)	43% (3/7)	14% (1/7)	14% (1/7)	14% (1/7)	43% (3/7)	71% (5/7)

Significant comorbidity defined as history of diabetes, current or previous ETOH abuse, current or previous smoker, COPD, CHF, HTN, or CKD.

Table 4

Comparison of symptomatic versus asymptomatic COVID-19 patients

	Symptomatic	Asymptomatic
Death	33.33% (1/3)	12.50% (1/8)
Stroke or CVA	0.00%	0.00%
Unplanned intubation	33.33% (1/3)	0.00%
DVT	33.33% (1/3)	12.50% (1/8)
Ventilator for >48 hours	33.33% (1/3)	0.00%
Acute renal failure	33.33% (1/3)	25.00% (2/8)
Blood transfusion	100.00% (3/3)	37.50% (3/8)
Sepsis	0.00%	0.00%

Zitek,[7] discussed COVID-19 testing. The nasopharyngeal swab with RT-PCR is the most widely used modality of testing. In vitro studies have shown high specificity and sensitivity for certain nasopharyngeal swab tests. However, with clinical use the nasopharyngeal swab has had questionable sensitivity for diagnosing COVID-19. The sensitivity is thought to be between 63% and 78%. Wang et al[8] found that of 398 nasopharyngeal swabs in patients with confirmed COVID-19, only 126 were positive. Therefore, it is possible that some patients in this study may have contracted the illness preoperatively, had a false-negative test prior to surgery, or contracted it preoperatively while being hospitalized.

Injuries sustained due to the pandemic varied. One observational study of acute orthopaedic trauma referrals at a Level 1 Trauma Center in London investigated trauma workload and referral case-mix.[9] The authors found that acute trauma referrals were almost halved during the 2020 pandemic when compared with 2019. Total operative cases fell by a third. Similarly, our institution saw a reduction in case volume mainly due to cancelling of elective cases as the COVID-19 pandemic struck our county. The authors reported an 11% rise in hip and polytrauma cases when compared with 2019. Hip fractures are often due to low energy falls indoors or around a patient's property and so therefore it would not likely have been affected by the pandemic and social distancing measures. There was an increase in falls from height from 5% in 2019 to 10% in 2020 possibly due to industrial/construction companies being exempt from the lockdown and social distancing measures, or the result of more people at home attempting home improvement endeavors. Motor vehicle crashes attributed 15% in both 2019 and 2020 despite a reduction in personal automobile use due to lockdowns. This was consistent with our data showing motor vehicle crashes accounting for 18% of injuries. The majority of patients in this study sustained a ground level fall (64%) while falls from height were 9%, again attributed to social distancing measures and patient isolation.

Of the 2 patients who died postoperatively, 1 was diagnosed with COVID-19 preoperatively. Both patients sustained ground level falls. One resulted in femoral neck fracture (31B3) (injury severity score 9) while the other led to a pilon fracture (43C2) (injury severity score 17). Both had a 5-day length of stay and required blood transfusion. One had COVID-19 symptoms on admission, developed a postoperative pneumonia, and acute renal failure postoperatively. Neither developed venous thromboembolism or pulmonary embolism.

Patients infected with COVID-19 develop a systemic inflammatory response which contributes to the high rate of venous thromboembolism in COVID-19 patients. Nicholson et al[10] discuss how the immune response and COVID-19 relate to venous thromboembolism. Inflammatory cytokine release with activation of thrombin and vascular endothelial injury, intensive care unit (ICU) admission, immobilization, hypoxia, and central venous lines can contribute to venous thromboembolism in COVID-19 patients. Patients with more severe disease are at higher risk for development of deep venous thrombosis (DVT). One study from Wuhan, China describes a 25% incidence of DVT in ICU patients with COVID-19.[11] In the current study 18% of patients developed DVT postoperatively with none developing pulmonary embolism. Tailoring anticoagulation specifically in the COVID-19 surgical population may prove challenging as increasing anticoagulant treatment may increase the risk of bleeding postoperatively. In our population, the routine use of both mechanical and chemical prophylaxis was undertaken postoperatively, with enoxaparin being the standard choice after hip fractures while aspirin was preferred for ankle trauma.

In the present study 46% of patients required postoperative transfusions. Baron et al[12] review management of patient anemia during the COVID-19 pandemic. Inflammatory and iron deficiency anemia are the most common etiologies in ICU patients. COVID-19 patients present a challenge when dealing with anemia and postoperative blood loss as appropriate hemoglobin levels should be maintained to provide adequate oxygenation. Transfusions are not without risk as transfusion-related acute lung injury would exacerbate an already tenuous pulmonary reserve and worsen patient outcomes.

Konda et al[13] recently published a risk assessment tool for elderly patients with low energy hip fractures. The Score for Trauma Triage in the Geriatric and Middle-Aged is an assessment tool used to predict inpatient mortality. It was modified to account for COVID-19 to provide orthopaedic surgeons with an algorithm to navigate risk during the pandemic. The modified Score for Trauma Triage in the Geriatric and Middle-Aged tool demonstrated value by triaging COVID-19 patients into the highest risk quartile, with a 35% rate of 30-day mortality. Furthermore, COVID-19 patients who are asymptomatic on initial presentation have a 12.5% inpatient mortality. Further development of risk stratification tools for orthopaedic trauma will provide a valuable guide as orthopaedic surgeons navigate patient care during the pandemic.

Beyond patient care, it is important for orthopaedic surgeons worldwide to be vigilant in donning personal protective equipment and following protocols. Guo et al[14] reported on 26 orthopaedic surgeons from 8 hospitals in Wuhan with COVID-19 disease. The suspected sites of exposure were general wards, public places in the hospital, operating rooms, ICU, and clinic. The majority of the suspected sites were general wards (79.2%). These data highlight the risk for healthcare providers and orthopaedic surgeons. Orthopaedic surgeons are at risk for contracting the disease and should be mindful when caring for COVID-19 patients, even outside of the operating room.

This retrospective study has multiple limitations. First, the study is retrospective in nature and is dependent on retrospective data collection. Second, the study's main population were Caucasian and therefore the results may not be fully applicable to the general population. Third, the mean age for our study population was 64.3 years. COVID-19 infection may affect outcomes differently for younger patients undergoing surgical management for orthopaedic injury. Finally, our study does not provide a control group. Historical controls from the available literature are provided to estimate frequencies for various

complications and injuries as follows. Ankle fractures: 0.23% mortality, 0.14% on ventilator for greater than 48 hours, 0.23% undergoing unplanned intubation, 0.05% postoperative acute renal failure, 0.29% postoperative sepsis, 0.25% pneumonia, 0.75% thromboembolic event, and 1.75% infectious complication.[15] Hip fractures: mortality 5.4% to 14.3%, 1.6% thromboembolic event, 14% pneumonia, 7% sepsis, 2.7% renal failure.[16,17] Tibia fractures: unplanned reintubation 0% to 0.50%, pneumonia 1.35% to 1.74%, DVT 0% to 0.50%, sepsis 0.45%to 0.50%, blood transfusion 2.25% to 5.72%, and mortality 0%.[18]

Overall, data from this small series suggests that surgical management in COVID-19 patients can be successfully accomplished with patient anticoagulation, hematologic, and pulmonary status in mind. Therapeutic anticoagulation should be optimized prior to the operating room to prevent development of venous thromboembolism while mitigating the risk of bleeding. Furthermore, patient hematologic status should be optimized preoperatively and intraoperative bleeding should be minimized so as to avoid blood transfusion. Reducing the need for intraoperative and postoperative blood transfusions will reduce the potential risk of transfusion-related acute lung injury in a patient population that has reduced pulmonary function.

The ongoing pandemic and realities facing health systems worldwide will shape modern healthcare as we know it as management strategies for orthopaedic trauma are developed in a postpandemic world. Further studies with long-term follow-up and greater statistical power are needed to better understand the effect of COVID-19 on surgical management of orthopaedic trauma as well as patient morbidity and mortality.

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