Orthopaedic trauma during COVID-19: Is patient care compromised during a pandemic?☆

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ABSTRACT

Background: The Coronavirus disease-2019 (COVID-19) placed unprecedented pressure on the healthcare system. Many institutions implemented a government-mandated restructured set of safety and administrative protocols to treat urgent orthopaedic trauma patients. The objective of this study was to compare two cohorts of patients, a COVID group and non-COVID control group, and to evaluate the effectiveness of safety measures outlined in the Rutgers Orthopaedic Trauma Patient Safety Protocol (ROTPSP). Secondary outcomes were to elucidate risk factors for complications associated with fractures and COVID-19.

Methods: Patients treated for orthopaedic traumatic injuries were retrospectively identified between March and May 2020, and compared to a series of patients from the same time period in 2018. Main outcome measures included surgical site infections (SSI), length of stay (LOS), post-operative LOS (poLOS), presentation to OR time (PORT), and length of surgery.

Results: After review, 349 patients (201 non-COVID, 148 COVID) undergoing 426 surgeries were included. Average LOS (11.91 days vs. 9.27 days, p = 0.04), poLOS (9.68 days vs. 7.39 days, p = 0.03), and PORT (30.56 vs. 25.59 h, p < 0.01) was significantly shorter in the COVID cohort. There were less SSI in the COVID group (5) compared to the non-COVID group (14) (p = 0.03). Overall complications were significantly lower in the COVID group. Patients receiving Cepheid tests had significantly shorter LOS and poLOS compared to patients receiving the RNA and DiaSorin tests (p < 0.01 and p < 0.01, respectively). The Cepheid test carried the best benefit-to-cost ratio, 0.10, p < 0.05.

Conclusion: The restructuring of care protocols caused by COVID-19 did not negatively impact perioperative complication rates, PORT or LOS. Cepheid COVID test type administered upon admission plays an integral role in a patient's hospital course by reducing both length of stay and hospital costs. This information demonstrates we can continue to treat orthopaedic trauma patients safely during the COVID-19 pandemic by utilizing strict safety protocols.

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1. Introduction

As of December 1, 2020, there have been 13.4 million COVID positive cases in the United States, leading to over 267,000 deaths. According to the CDC, New Jersey ranks second in the US with 190 deaths/100,000 cases.[1,2] The COVID-19 pandemic put extraordinary pressure on the healthcare system of New Jersey, as hospitals diverted both physical and human resources to meet rising critical care demands. Additionally, the resources normally used to provide orthopaedic care were repurposed.[3] Despite the re-allocation of resources, patients with orthopaedic trauma continued to present to the trauma bay.[4]

Historically, SSI rates described for "all-comer" orthopaedic

trauma patients range from 1.3% to 15.6%.[5—8] The causative agent of COVID-19, SARS-CoV-2, has been shown to be transmitted via respiratory secretions and may be spread during orthopaedic procedures.[9—12] This raises concern for increased perioperative complications, especially increased complication and morality rates in COVID positive hip fracture patients.[13—15]

Current literature has described individual hospital experiences in response to COVID-19, safety protocols, and perioperative outcomes with isolated extremity fractures. To the best of our knowledge, no study has evaluated the effectiveness of the implemented safety measures for all comer orthopaedic trauma patients. In addition, no study has evaluated 180-day outcomes. Moreover, there is a paucity of literature that exists regarding the impact of COVID test type ordered and its relationship to the associated hospital course.

The objective of this study was to compare two cohorts of patients, a COVID group and non-COVID control group that presented during the same seasonal period two years ago, to evaluate the effectiveness of safety measures taken in response to COVID-19 to elucidate potential risk factors for complications associated with traumatic orthopaedic injuries and COVID-19. We hypothesized that COVID related obstacles would limit the ability to provide urgent and effective orthopaedic care resulting in increased SSIs, increased presentation to OR time, increased overall LOS, increased poLOS and decreased length of surgery.

2. Methods

2.1. Patient selection

Following IRB approval, patients treated for urgent orthopaedic injuries that presented to a Level 1 trauma center were retrospectively identified between March 9, 2020 and May 26, 2020. This time period signified a declared state of emergency and the resumption of elective cases in the state of New Jersey. Patients from the same time period in 2018 were selected as a non-COVID control group. Inclusions criteria included all orthopaedic trauma patients requiring urgent or emergent surgical intervention. Exclusion criteria included age less than 18, 2018 elective orthopaedic procedures, same day surgery and oncology patients.

2.2. Patient characteristics

Electronic medical records were reviewed and data recorded included patient demographics, body mass index, comorbidities, American Society of Anesthesiologists (ASA) score, and Glasgow Coma Score (GCS). Variables related to the injury and surgery were collected, including anatomic site of injury, AO classification, presence of open fracture, COVID test type ordered, COVID status at time of surgery (positive '+', negative '-', unknown 'u'), final COVID status (+, -), repeat COVID status (+, -) and room of surgery.

2.3. Outcomes

The primary outcomes were LOS, poLOS, PORT and length of surgery. Secondary outcomes were post-surgical complications.

2.4. Safety protocol and efficiency measures

In order to minimize spread of disease between care providers and patients, and prevent depletion of 'limited resources', our institution implemented the creation the Rutgers Orthopaedic Trauma Pandemic Patient Safety Protocol (ROTPSP). The protocol employed a rotating four-team system of residents that functioned independently of one another. The teams transitioned every four

days and had no contact with other team members. Patient care transitions were conducted over videoconference in separate rooms.

Patients that required urgent or emergent surgery warranted COVID-19 testing with one of three tests: Cepheid, DiaSorin, or SARS-Cov2-RNA ('RNA'). Due to limitations in supplies, the DiaSorin and Cepheid tests were to be ordered for patients that required social disposition for emergent bed management from the ED. The DiaSorin test was to be ordered between 7am and 7pm and the Cepheid test was to be ordered the remaining time. The SARS-Cov2-RNA could be ordered at any time. Outside of the Cepheid test, sample runs were conducted in batches at designated time points throughout the day. Urgent surgical intervention proceeded with the assumption that the patient may be COVID+ and without requirement to wait for the test result. COVID-U or COVID + patients were placed in designated negative pressure ORs. All intubations and extubations were performed with the least number of personnel and maximal personal protective equipment (PPE). Surgical site sterilization and draping was performed in usual sterile fashion, which was consistent between the two cohorts. During the procedure, the surgical staff wore maximal PPE. Following the OR, COVID status determined the patient disposition and appropriate droplet and contract precautions were taken for COVID + patients.

At our institution, the discharge protocol is initiated the moment the patient has a discharge plan and entails a combined effort from social workers, case managers, various therapist and the varying services treating the patient. The only difference in our discharge protocol during COVID compared to the non-COVID time period was obtaining a COVID test prior to the anticipated day of discharge. This was so that we would have a COVID test result the morning of discharge, as patients sent to rehab facilities required a negative COVID test. Home discharge with or without home health aide and/or family support was strongly encouraged.

2.5. Cost analysis

A cost analysis was performed, accounting for reagent, instrument and hospital room and board costs, as listed in the charge description master transparency sheet. Analysis includes costs incurred over the course of the pandemic and a long-term model of each testing system.

2.6. Statistical analysis

Patient, injury, and surgical characteristics between the two cohorts were compared using chi-square or Fisher's exact test. A two tailed T-test or Wilcoxon rank-sum test was used for continuous parametric or non-parametric variables, respectively. Normality was assessed with the Shapiro-Wilk test. Kaplan-Meier and Cox proportional hazards regression models were performed to assess the primary outcomes and predictors of each event. ANOVA was performed to assess COVID-19 testing methods on LOS and cost. The assumption of homogeneity of variances was tested and not satisfied based on the Levene's F test, instead a Brown-Forsythe test was used. A p-value of <0.05 was used to define statistical significance. Data were analyzed using SPSS (IBM Corp., Armonk, NY).

3. Results

3.1. Patient demographics

Patient demographics are summarized in Supplemental Table 1. After accounting for all patients that presented to the ED requiring

an orthopaedic consult, there were 306 patients in 2020 and 474 patients in 2018. Surgery was performed in 148 of 306 (48%) in the COVID cohort and in 201 of 474 (42%) of patients in the non-COVID cohort, p = 0.10. The COVID cohort had 148 patients who underwent 182 surgeries, while the non-COVID cohort had 201 patients who underwent 244 surgeries. The COVID cohort had a smaller proportion of African American (43.4% vs. 54.9%, respectively, p = 0.02) and a larger proportion of Hispanic (38.4% vs. 27.0%, respectively, p = 0.01) (Supplemental Table 1). Compared to the 2018 cohort, the COVID cohort had more patients with chronic obstructive pulmonary disease (7 vs. 1, p = 0.02) and diabetic neuropathy (6 vs. 1, p < 0.05) (Supplemental Table 2).

3.2. Injury characteristics

A total of 154 (63.1%) fractures were operated on in 2018 compared to 134 (73.6%) in 2020. There were no differences in injury pattern by AO classification (type A p = 0.95, type B p = 0.79, type C p = 0.75) (Supplemental Table 4). There were significantly less femur injuries during COVID compared to the non-COVID cohort (21 vs. 45, p = 0.01). There were no other differences in rate of injury by anatomic site and the percentage of open injuries was similar between cohorts (Supplemental Table 3).

3.3. Main outcomes

During COVID compared to the non-COVID cohort, the average LOS (9.27 days versus 11.91 days, respectively, p = 0.04), poLOS (7.39 days versus 9.68 days, respectively, p = 0.03) and PORT (25.59 h versus 30.56 h, respectively, p < 0.01) were all shorter. There was no difference in average surgery length (Table 1). A Cox proportional hazards model demonstrated that increased age (1.01, 95% CI 1–1.02, p < 0.05), Cepheid COVID test (2.78, 95% CI 1.7–4.53, p < 0.05), and not obtaining a COVID test (1.94, 95% CI 1.31–2.87, p < 0.05), were independent factors that significantly reduced LOS. The hazards model also demonstrated that older age (1.01, 95% CI 1–1.02, p < 0.05), Cepheid COVID test (3.06, 95% CI 1.87–5.01, p < 0.05), and not obtaining a COVID test (1.98, 95% CI 1.34–2.92, p < 0.05), were independent factors that significantly reduced poLOS. AO type C fractures and ASA classes 2,3,4 were independent risk factors for increased surgery length (Table 2).

3.4. Secondary outcomes

Eleven non-COVID patients had SSIs and underwent 14 surgeries, while the 5 COVID patients had SSIs and underwent 5 surgeries (p = 0.03) (Table 1). There were significantly more non-infectious complications in the non-COVID group (59) than in the COVID group (27) within the first 180 days after surgery (p = 0.02), but no difference in rate of mortality, DVT/PE, MI, pneumonia, sepsis, or compartment syndrome.

Table 1
Summary of primary and secondary outcomes.

Outcome	Non-COVID	COVID	p-value
Avg LOS (days)	11.91	9.27	0.04
Avg Post-Op LOS (days)	9.68	7.39	0.03
Avg Presentation to OR (hrs)	30.56	25.59	0.001
Avg Surgery Length (hrs)	2.65	2.77	0.74
Total documented SSI (surgeries)	11 (14)	5 (5)	0.03
Non-Infectious Complications	48	22	0.04
Overall Complications	59	27	0.02

3.5. COVID tests

There were 134 COVID tests obtained pre-operatively (65 SARS-RNA, 30 Cepheid, 39 DiaSorin) on orthopaedic trauma patients, while 48 patients did not receive a preoperative test (Supplemental Table 5A–D). Patients who received a Cepheid test had a shorter LOS (4.2 ± 4.2 days) than patients who received a DiaSorin (5.4 ± 6.3 days; p < 0.01) or SARS-RNA (11.9 ± 8.8 days; p = 0.02) (Supplemental Table 6). Similar findings existed with regards to variability in poLOS by method of pre-operative COVID testing. There was no difference in Cepheid test administration by age, p = 1, Supplemental Table 7.

3.6. Pre-surgery COVID status

There were 5 COVID+, 108 COVID-, and 69 COVIDu results prior to surgery (Table 3). There was no relationship between pre-surgery COVID status and average LOS, average poLOS, average PORT and average surgery length compared to each other and to the non-COVID cohort (p > 0.05).

3.7. COVID positive patients

Seven orthopaedic trauma patients, undergoing 8 surgeries, tested positive for COVID during the pandemic (Supplemental Table 9). None of the four patients that were COVID + at the time of surgery suffered any complications within 180 days. Of the 2 COVIDu patients, one subsequently resulted positive and died secondary to hypoxic respiratory failure, while the other recovered without any complications within 180 days. There was one nosocomial COVID infection; however, the patient recovered without other complications within 180 days.

3.8. Cost analysis

Total cost for the patients tested by Cepheid, DiaSorin and SARS-RNA tests were between $975,576.99 − $2,599,670.43, $3,639,038.82 − $9,697,134.85 and $6,550,462.66 - $17,455,356.45, respectively. Cost analysis demonstrated the Cepheid system to have the best benefit-to-cost ratio (BCR 0.10, p < 0.001) when compared to all other testing systems (Table 4). There were no differences in average cost and LOS between all patients receiving a COVID test during the pandemic period compared to patients in the non-COVID period (Supplemental Table 8).

4. Discussion

In lieu of recent surges in COVID cases, it becomes paramount to determine whether operating under such conditions remains safe. The COVID-19 pandemic created a unique work environment with redistribution of hospital personnel and limitations in available resources. Despite limitations in resources, patients presenting to our level 1 trauma center presented to the OR quicker and experienced shorter post-operative hospital stays (Table 1). Additionally, when accounting for all patients that presented to the ED, there was no increased likelihood to discharge or perform non-operative management of a patient during COVID as compared to the non-COVID cohort. This may be in part due to incentives to discharge patients from the social worker perspective due to the relative 25% decrease in case volume we experienced. Another possible explanation is better OR availability. Although there was a reduction in OR staff, only urgent cases were permitted across all surgical specialties which translated to less "competition" for block time. Bhattacharyya et al. demonstrated that less competition due to a dedicated orthopaedic trauma operating room improved

Table 2
Cox proportional hazards model for length of outcomes.

Variable	Overall Length of Stay (Hazard Ratio, 95% CI)	Post-Op Length of Stay (Hazard Ratio, 95% CI)	Time from Presentation to OR (Hazard Ratio, 95% CI)	Length of Surgery (Hazard Ratio, 95% CI)
Age	1.01 (1–1.02)*	1.01 (1–1.02)*	1 (0.99–1.01)	1.01 (1–1.02)*
Male (vs. Female)	0.97 (0.74–1.26)	0.97 (0.75–1.27)	0.99 (0.77–1.28)	1.12 (0.86–1.44)
Race (vs. Caucasian)				
African American	1.2 (0.85–1.7)	1.3 (0.92–1.83)	0.92 (0.64–1.31)	1.06 (0.75–1.5)
Hispanic/Latino	1.45 (1–2.11)	1.45 (1–2.11)	1.4 (0.97–2.04)	1.04 (0.72–1.5)
Other	1.25 (0.55–2.83)	1.12 (0.49–2.54)	1.82 (0.8–4.17)	0.53 (0.23–1.2)
COVID testing (vs. 2018 Cohort)				
RNA	0.95 (0.67–1.35)	0.98 (0.69–1.39)	1.05 (0.75–1.48)	0.86 (0.61–1.22)
Cepheid	2.78 (1.7–4.53)*	3.06 (1.87–5.01)*	1.03 (0.63–1.67)	1.36 (0.84–2.2)
DiaSorin	0.85 (0.54–1.33)	0.84 (0.54–1.31)	1.53 (1–2.33)	0.8 (0.52–1.23)
Not Obtained	1.94 (1.31–2.87)*	1.98 (1.34–2.92)*	0.88 (0.6–1.28)	0.75 (0.51–1.11)
AO Classification (vs. A)				
B	0.82 (0.6–1.11)	0.86 (0.63–1.17)	0.76 (0.56–1.03)	0.74 (0.55–1)
C	0.83 (0.6–1.13)	0.83 (0.61–1.13)	1.1 (0.82–1.47)	0.7 (0.52–0.95)*
Chronic Obstructive Pulmonary Disease	1.14 (0.45–2.9)	1.02 (0.4–2.6)	2.36 (0.93–5.98)	0.9 (0.33–2.42)
Diabetic Neuropathy	0.61 (0.19–1.97)	0.61 (0.19–1.94)	0.64 (0.2–2.06)	3.72 (1.14–12.15)*
Glasgow Coma Scale ≤8 (vs. >8)	0.4 (0.2–0.77)*	0.38 (0.19–0.74)*	0.7 (0.36–1.35)	0.62 (0.32–1.24)
ASA Class (vs. 1)				
2	0.64 (0.41–1)	0.64 (0.41–0.98)*	1.11 (0.71–1.73)	0.59 (0.39–0.91)*
3	0.31 (0.19–0.51)*	0.33 (0.2–0.53) *	0.76 (0.46–1.24)	0.43 (0.27–0.68)*
4	0.25 (0.13–0.49)*	0.31 (0.16–0.61) *	0.71 (0.36–1.39)	0.22 (0.11–0.44)*

*Indicates significance p < 0.05.

Table 3
COVID Pre-Surgery Status versus primary outcomes.

COVID Pre-Surgery Status, Total	N	Avg LOS (d)	Avg Post Op LOS (d)	Avg Presentation to OR (hrs)	Avg Surgery Length (hrs)
Positive	5	13.71	12.39	12.78	3.98
Negative	108	8.62	6.27	28.70	2.55
Unknown	69	9.97	8.81	21.32	3.07
Non-COVID	244	11.91	9.68	30.56	2.65
Positive vs. Negative vs Unknown	p-value	0.43	0.18	0.38	0.06
Positive vs. Negative vs Unknown vs Non-COVID	p-value	0.16	0.11	0.40	0.18

Table 4
Cost analysis by pre-operative COVID test type.

COVID Test Type	SARS-RNA A	SARS-RNA B	DiaSorin	Cepheid A	Cepheid B	p-value
N	65	65	39	30	30	
Length of stay (days), mean ± SD	12.9 ± 15.3	12.9 ± 15.3	11.9 ± 8.8	4.3 ± 4.2	4.3 ± 4.2	<0.001*
Unit Cost (dollars)	169,900	120,000	60,000	35,000	530,000	
Reagent Cost (dollars)	41	22.55	41	39.50	39.50	
Run Time per sample (min)	330	270	90	45	60	
Sample loading	Non-continuous	Non-continuous	Non-continuous	Continuous	Continuous	
Minimum Hospital Charges (dollars), mean ± SD	100,775 ± 120,199	100,775 ± 120,199	93,308 ± 68,872	33,404 ± 32,982	33,404 ± 32,982	<0.001*
Maximum Hospital Charges (dollars), mean ± SD	268,541 ± 320,300	268,541 ± 320,300	248,643 ± 183,527	89,014 ± 87,889	89,014 ± 87,889	<0.001*
Benefit/Cost Ratio	0.01	0.02	0.03	0.01	0.10	<0.001*

*Indicates significance p < 0.05.

operating room efficiency, patient outcomes, reduced LOS, lowered complications and resulted in hospital cost savings and supports our findings.[16,17]

Recent literature has shown that individuals with more comorbidities are predisposed to compromised outcomes due to the coronavirus, thus limiting length of hospital stays to decrease risk of nosocomial infections is of utmost importance.[18] Additionally, LOS has been used as a metric to determine which procedures should be performed during this difficult time because longer hospital stays may exhaust more coveted resources and may place patients at increased risk of infection.[2] Furthermore, LOS can be used as a metric to assess the efficiency of hospital personnel to effectively rehabilitate patients after surgical intervention.[19] Prachand et al. proposed the medically necessary, time-sensitive

procedures (MeNTS) to efficiently manage resource scarcity and provider risk during the COVID-19 pandemic. A higher MeNTS score for each factor is associated with poorer perioperative patient outcome, increased COVID-19 transmission risk to the healthcare team, and increased hospital resource use. Surgery times greater than 120 min and LOS greater or equal to 4 days carry high MeNTS scale scores.[20] Although our average LOS during the COVID-19 pandemic was 9.27 days and our average surgery time was 2.77 h, we did not see poorer perioperative patient outcomes compared to the 2018 cohort, contrary to the proposed risks suggested by the MeNTS score (Table 1).

Within 180 days, there were fewer complications during the COVID cohort compared to the non-COVID cohort (59 vs. 27, respectively p = 0.02) (Table 1). There was only one mortality

amongst COVID positive patients. This is in contrast to Egol et al. and Lebrun et al. who both reported an increased complication and mortality rate in COVID positive patients suffering hip fractures.[13,14] This may be due to increased patient age in their sample compared to ours (average age 83 versus 43 in our cohorts), as studies on COVID demonstrates that patients >80 have an increased mortality.[1] Despite the age difference, our adherence to PPE and limited OR traffic may have facilitated our low complication rates.[9,10]

When evaluating just SSI, we found an increased number of SSI in the 2018 cohort (11 (4.5%) vs. 5 (2.7%), respectively, p = 0.03). Our SSI rates fall within the lower end of the spectrum between 1.3% and 15.6% for SSI rates described for all-comer orthopaedic trauma patients.[5–8] One possible explanation for the lower perioperative complications is that during the pandemic there was increased vigilance to safety, most notable in the OR setting. For patients that were COVID+ and COVIDu, the circulator would request supplies from the hallway in order to limit in-and-out traffic. Additionally, the institution's safety protocol implemented teams that limited the number of people in the OR. This reduces contamination risk, as Ritter et al. demonstrated the number of colony-forming units in the OR directly correlates to the number of people in the OR. Additional studies have demonstrated reduction of SSIs with less OR traffic.[10,21,22]

Cepheid COVID test significantly reduced LOS and poLOS when compared to the 2018 cohort and to the other COVID tests. This may stem from the design and efficiency of this COVID test. The Cepheid system used at our institution has the capability to run a maximum of 4 samples with results every 45 min, but allows continuous loading of samples when any sample concludes. On the contrary, despite the other tests allowing for larger samples numbers, the sample turnover is much slower. Quicker COVID status identification allowed faster initiation of the discharge process. This is also the likely reason that patients undergoing COVID testing with the Cepheid test incurred nearly 3-fold lower maximum hospital charges and the best benefit-cost ratio among the four tests (Table 4).

Limitations of this study include its retrospective design. To account for the retrospective design, we compared the patients treated during the pandemic to cohort of patients from the same seasonal period prior to the pandemic. Second, although there were no differences in injury pattern by AO classification between the two cohorts, we were not able to fully evaluate the differences between fracture characteristics, which may affect surgical time. Third, although we only had one COVID related death, these results should be interpreted with caution due our low samples size of COVID + patients. However, we present two large cohorts of patients with 180-day perioperative findings that demonstrate overall patient perioperative complications were not significantly increased during the COVID-19 pandemic. Lastly, long-term outcomes are not available at this time and it is possible for mortality and complication rates to increase. However, we have offered the longest possible outcome study to date.

Nevertheless, this study has many strengths. To the best of our knowledge, we are the first study to report results on all presenting orthopaedic trauma outcomes compared to a similar cohort of non-COVID patients.[13,14,23] We report 180-day post-operative data, which is the longest to date. In addition, this is the first study to analyze operational efficiency during the pandemic in relation to COVID test type ordered. Furthermore, no prior studies evaluated the cost analysis of differing COVID tests.

In conclusion, despite changes in typical practice algorithms due to the COVID-19 pandemic, the metrics of orthopaedic trauma patient care were overall unaffected. With the implementation of the ROTPSP, we experienced quicker presentation time to operating room and shorter total hospital and postoperative length of stays,

while having no difference in mortality and complications within 180 days. This information demonstrates we can continue to treat orthopaedic trauma patients safely during a pandemic state.

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Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jcot.2021.04.023.

References

1. *Control CfD. CDC COVID Data Tracker*; 2020. https://www.cdc.gov/covid-data-tracker/- testing. https://www.cdc.gov/covid-data-tracker/- testing.
2. Massey PA, McClary K, Zhang AS, Savoie FH, Barton RS. Orthopaedic surgical selection and inpatient paradigms during the coronavirus (COVID-19) pandemic. *J Am Acad Orthop Surg*. 2020.
3. Konda SR, Dankert JF, Merkow D, et al. COVID-19 response in the global epicenter: converting a New York City level 1 orthopedic trauma service into a hybrid orthopedic and medicine COVID-19 management team. *J Orthop Trauma*. 2020;34(8):411–417.
4. DePhillipo NN, Larson CM, O'Neill OR, LaPrade RF. Guidelines for ambulatory surgery centers for the care of surgically necessary/time-sensitive orthopaedic cases during the COVID-19 pandemic. *J Bone Joint Surg Am*. 2020 Jun 3;102(11): 933–936. Epub 2020/04/14.
5. Avinash M, Rajasekaran S, Aiyer SN. Unplanned 90-day readmissions in a specialty orthopaedic unit—a prospective analysis of consecutive 12729 admissions. *J Orthop*. 2017;14(2):236–240.
6. Dy CJ, Dossous P-M, Ton QV, Hollenberg JP, Lorich DG, Lane JM. The medical orthopedic trauma service: an innovative multidisciplinary team model that decreases in-hospital complications in patients with hip fractures. *J Orthop Trauma*. 2012;26(6):379–383.
7. Phruetthiphat O-a, Willey M, Karam MD, Gao Y, Westerlind BO, Marsh JL. Comparison of outcomes and complications of isolated acetabular fractures and acetabular fractures with associated injuries. *J Orthop Trauma*. 2017;31(1): 31–36.
8. Metcalfe D, Olufajo OA, Zogg CK, et al. Unplanned 30-day readmissions in orthopaedic trauma. *Injury*. 2016;47(8):1794–1797.
9. Philips B, Fergusson S, Armstrong P, Anderson F, Wildsmith J. Surgical face masks are effective in reducing bacterial contamination caused by dispersal from the upper airway. *Br J Anaesth*. 1992;69(4):407–408.
10. Panahi P, Stroh M, Casper DS, Parvizi J, Austin MS. Operating room traffic is a major concern during total joint arthroplasty. *Clin Orthop Relat Res*. 2012;470(10):2690–2694.
11. Lynch RJ, Englesbe MJ, Sturm L, et al. Measurement of foot traffic in the operating room: implications for infection control. *Am J Med Qual*. 2009;24(1): 45–52.
12. Weiser MC, Shemesh S, Chen DD, Bronson MJ, Moucha CS. The effect of door opening on positive pressure and airflow in operating rooms. *JAAOS-J Am Acad Orthop Surg*. 2018;26(5):e105–e113.
13. Egol KA, Konda SR, Bird ML, et al. Increased mortality and major complications in hip fracture care during the COVID-19 pandemic: a New York city perspective. *J Orthop Trauma*. 2020;34(8):395–402.
14. LeBrun DG, Konnaris MA, Ghahramani GC, et al. Hip fracture outcomes during the COVID-19 pandemic: early results from New York. *J Orthop Trauma*. 2020;34(8):403–410.
15. Stinner DJ, Lebrun C, Hsu JR, Jahangir AA, Mir HR. The orthopaedic trauma service and COVID-19: practice considerations to optimize outcomes and limit exposure. *J Orthop Trauma*. 2020;34(7):333–340.
16. Bhattacharyya T, Vrahas MS, Morrison SM, et al. The value of the dedicated orthopaedic trauma operating room. *J Trauma Acute Care Surg*. 2006;60(6): 1336–1341.
17. Runner R, Moore Jr T, Reisman W. Value of a dedicated Saturday orthopaedic trauma operating room. *J Orthop Trauma*. 2016;30(1):e24–e29.
18. Fan J, Liu X, Shao G, et al. The epidemiology of reverse transmission of COVID-

19 in Gansu Province, China. *Travel Med Infect Dis*. 2020:101741.

19. Ottenbacher KJ, Smith PM, Illig SB, Linn RT, Ostir GV, Granger CV. Trends in length of stay, living setting, functional outcome, and mortality following medical rehabilitation. *Jama*. 2004;292(14):1687–1695.

20. Prachand VN, Milner R, Angelos P, et al. Medically-necessary, time-sensitive procedures: a scoring system to ethically and efficiently manage resource scarcity and provider risk during the COVID-19 pandemic. *J Am Coll Surg*. 2020;231(2):281–288.

21. Nelson CL. Prevention of sepsis. *Clin Orthop Relat Res*. 1987;(222):66–72.

22. Smith EB, Raphael IJ, Maltenfort MG, Honsawek S, Dolan K, Younkins EA. The effect of laminar air flow and door openings on operating room contamination. *J Arthroplasty*. 2013;28(9):1482–1485.

23. Kayani B, Onochie E, Patil V, et al. The effects of COVID-19 on perioperative morbidity and mortality in patients with hip fractures: a multicentre cohort study. *Bone Joint J*. 2020;102(9):1–10.