

Operating Room Efficiency of Orthopedic Surgery During the COVID-19 Era

Stefan W. Koester, MS; Stephen Chenard, MSc; Chinonso Ani, BS; Justin Moo Young, MD; D. Campbell Liles, MD; Robert Dambrino, MD; Vikram Tiwari, PhD; and Byron F. Stephens, MD, MSCI

The World Health Organization classified the SARS-CoV-2 outbreak as a pandemic on March 11, 2020.¹ Since then, countries have struggled to maintain normalcy while taking the proper precautions to ensure the health and safety of their citizens. As of December 31, 2021, the COVID-19 pandemic had infected 56 million people and resulted in 850,000 deaths in the United States,² resulting in significant strain on the American health care system.

During the initial stages of the pandemic, hospitals made drastic operational changes to avoid overcrowding and medical supply disruptions. CMS recommended that hospitals minimize and postpone nonessential surgical procedures.³ Research analyzing the initial shutdown period of March through April 2020 showed a 48% decrease in total surgical procedure volume.⁴ To address the sudden decline in surgical volume, the American College of Surgeons, the American Society of Anesthesiologists, the Association of periOperative Registered Nurses, and the American Hospital Association released a joint statement offering guidelines for the resumption of elective surgeries that included measures of preoperative COVID-19 testing among patients and staff, adequate personal protective equipment (PPE) supply management, and case prioritization based on patient COVID-19 status.⁵

Although these measures helped to rebound surgical procedure volume, the effects of the COVID-19 pandemic burdened operating room (OR) efficiency, and hospital staff infections caused last-minute OR staffing changes and shortages. The prioritization of urgent/emergent and COVID-19–related cases resulted in furloughs, layoffs, and reassignments that affected medical personnel staffing. As new guidance regarding elective procedures emerged, hospitals adjusted to anti-infective measures and PPE utilization that strained the coordination of OR procedures.

Based on the inherently inefficient nature of these pandemic-driven changes in guidelines, policy, and staffing, we hypothesized that COVID-19 would lead to a decrease in overall OR efficiency. To assess the extent of any such potential effect, we analyzed the impact and burden of the pandemic on orthopedic OR efficiency at our tertiary academic medical center.

ABSTRACT

OBJECTIVE: The COVID-19 pandemic forced operating rooms (ORs) to adopt new safety protocols. Although these measures protected the health of patients and providers, their impact on OR efficiency remains unclear. Our objective was to further elucidate the effects of COVID-19 on orthopedic surgery OR efficiency.

STUDY DESIGN: This was a retrospective study of 14,856 orthopedic surgeries performed between December 1, 2019, and October 31, 2021.

METHODS: Institutional perioperative databases were used to identify relevant orthopedic surgeries. The onset of the COVID-19 period was set as March 12, 2020, when a state of emergency was declared in Tennessee. Both 90-day periods before and after this date were used for comparative analysis of the pre-COVID-19, peak-restrictions, and post-peak-restrictions time periods. Delay of first case start time and turnover time between cases were used as primary measures of efficiency.

RESULTS: There were 1853 pre-COVID-19 cases, 1299 peak-restrictions cases, and 11,704 post-peak-restrictions cases analyzed. Delay of first case start time was found to be significantly different among the time periods (mean [SD] minutes, 7 [14] vs 8 [18] vs 7 [17], respectively; $P < .001$). Turnover time between cases was also significantly different among the time periods (62 [49] vs 66 [51] vs 64 [51]; $P = .002$).

CONCLUSIONS: Although significant, there was minimal absolute change in orthopedic OR efficiency during the onset of the pandemic. These results suggest that the protocols enacted at our institution appropriately maintained orthopedic OR efficiency, even in the context of the rapidly increasing COVID-19 burden.

Am J Manag Care. 2023;29(11):e348-e352. doi:10.37765/ajmc.2023.89460

METHODS

To analyze the effect of COVID-19 on OR efficiency, institutional perioperative databases at a single, high-volume, tertiary academic medical center were queried for surgical procedures performed from December 1, 2019, to October 31, 2021. The onset of COVID-19 for analytic purposes was chosen as March 12, 2020, when Tennessee declared a state of emergency. A 90-day period before and after this day was used for comparative analyses for the pre-COVID-19, peak-restrictions, and post-peak-restrictions time periods. The peak-restrictions period was defined as the 90-day period following March 12, 2020. For longitudinal comparison purposes, the post-peak-restrictions period was defined as the months following the first peak until October 31, 2021. The burden of COVID-19 was defined based on a hospital-maintained COVID-19 census describing how many admitted patients with COVID-19 were present in the hospital at a given time. The average of this census was performed on a month-by-month basis and then adjusted to the respective figure.

Elective and nonelective orthopedic surgery cases were included in the analysis. Outcomes included first-start delays (defined as the difference in time between scheduled start time and actual start time) and OR turnover time between orthopedic surgery cases (defined as the time between 1 patient leaving and the next patient entering the OR). Analyses using preset threshold times were used to adjust for normal leniency in OR scheduling (15 minutes for the first start and 90 minutes for turnover, as is standard practice in our perioperative assessments at our center). Furthermore, the proportion of cases that started more than 15 minutes early was compared among the 3 time periods. This allowance for a 15-minute window for the first-start time is termed *adjusted first-start time* and an allowance for a 90-minute turnover time is termed *adjusted turnover time*. Statistical analysis, including data aggregation, was performed using R, version 4.0.1 (R Foundation for Statistical Computing). Chi-square test and Fisher exact test were used for categorical comparisons. Significance was defined as $P < .05$.

RESULTS

First-Start Time

First-start time was analyzed in 617 pre-COVID-19 cases, 442 peak-restrictions cases, and 3854 post-peak-restrictions cases. The mean (SD) delay length was found to be significantly different among the time periods, but the magnitude of increase in minutes was immaterial (mean minutes, 7 [14] vs 8 [18] vs 7 [17], respectively; $P < .001$) (Table 1). The proportion of cases delayed beyond a 15-minute threshold

TAKEAWAY POINTS

The COVID-19 pandemic necessitated new protocols to ensure the safety of patients and health care providers. However, the effects of these protocols on operating room (OR) efficiency have yet to be fully elucidated. Using institutional perioperative databases, we investigated the impact of COVID-19 on orthopedic surgery OR efficiency.

- ▶ Previous reports from Italy and the United Kingdom demonstrate dramatically decreased efficiency during the pandemic.
- ▶ In contrast, we demonstrate minimal absolute change in orthopedic OR efficiency at our institution during the onset of the pandemic.
- ▶ These results suggest that the protocols put into place at our institution were appropriate for maintaining orthopedic OR efficiency even in the context of a rapidly increasing COVID-19 burden.

TABLE 1. First-Start Time Analysis

Characteristic	Pre-COVID-19 (n=617)	Peak restrictions (n=442)	Post-peak restrictions (n=3854)	P
Delay length, mean (SD) minutes	7 (14)	8 (18)	7 (17)	<.001
Cases delayed > 15 min, n (%)	96 (16%)	79 (18%)	614 (16%)	.54
Early cases, n (%)	134 (22%)	89 (20%)	1125 (29%)	<.001
Early cases > 15 min, n (%)	40 (6.5%)	27 (6.1%)	413 (11%)	<.001

was not significantly different among the 3 time periods ($P > .05$). However, the proportion of cases that started early was significantly different among the 3 time periods, with the highest proportion starting early during the post-peak-restrictions period (1125/3854 cases [29%]) compared with the peak-restrictions (89/442 [20%]) and pre-COVID-19 (134/617 [22%]) ($P < .001$) periods. The temporal relationship between COVID-19 case burden and adjusted first-start delay from December 2019 to October 2021 is shown in Figure 1.

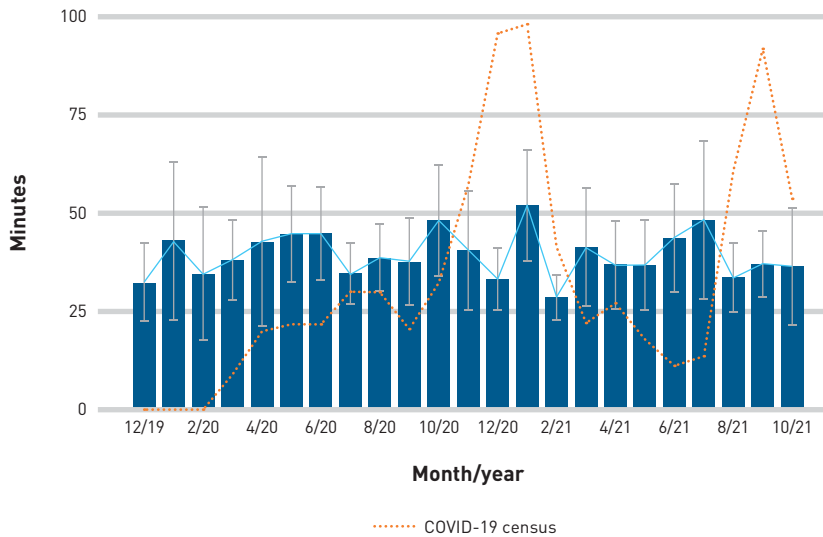
Turnover Time

Turnover time, which was assessed in 1236 pre-COVID-19 cases, 857 peak-restrictions cases, and 7850 post-peak-restrictions cases, experienced a significant but immaterial increase during the peak-restrictions period relative to the pre-COVID-19 period (mean [SD] minutes, 66 [51] vs 62 [49]) and has since remained stable (64 [51]; $P = .002$). The proportion of cases with turnover time past 90 minutes and mean times past the 90-minute threshold were not significantly different (Table 2). The temporal relationship between COVID-19 case burden and adjusted turnover time from December 2019 to October 2021 is shown in Figure 2, which demonstrates a slight initial increase in turnover time delay at the start of the COVID-19 pandemic, which stabilized with little variation thereafter.

DISCUSSION

Although the practice of modern medicine places an increasing emphasis on clinical throughput and productivity, health care

FIGURE 1. Adjusted First-Start Delay in Operating Room Efficiency Relative to COVID-19 Census



workers must prioritize the quality of the care they provide while simultaneously striving to maximize efficiency. Because the OR plays such a financially important role at most hospitals, maximizing its efficiency has major implications on cost savings, patient satisfaction, and medical team morale.⁶ The quality and safety of OR processes are of utmost importance in providing optimal outcomes for patients undergoing surgery. Furthermore, such processes are crucial for protecting the health of the operating team and must not be sacrificed for efficiency. Therefore, optimal utilization of OR time plays a critical role in achieving the proper balance between efficiency and safety.

The COVID-19 pandemic has had major impacts on the efficiency and safety of OR processes at hospitals around the world.^{7,8} Although all surgical subspecialties have been affected by rising case counts, the impacts of increasing COVID-19 case burden on orthopedic OR efficiency have yet to be fully elucidated. Therefore, our group set out to investigate the effects of COVID-19 burden on orthopedic OR efficiency at our tertiary academic medical center before the COVID-19 pandemic, during peak COVID-19, and after the peak period in a large, single-center, tertiary care hospital.

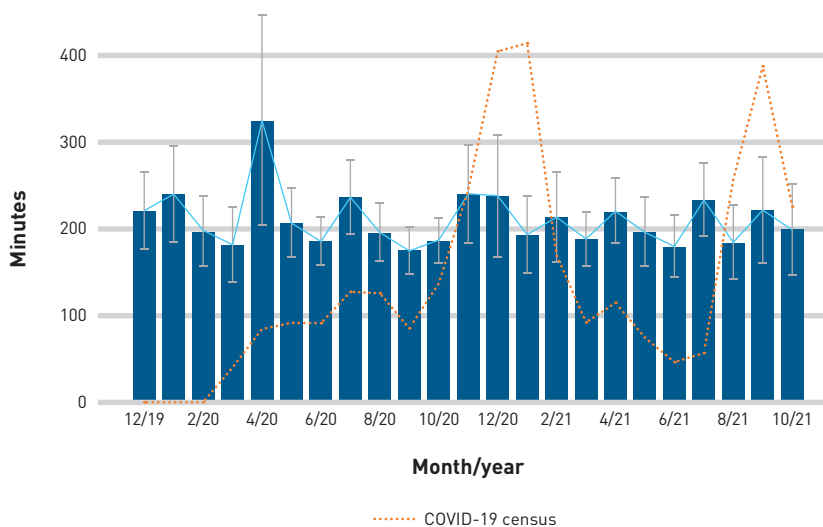
During the compared time periods, we found that the COVID-19 case burden had an insignificant effect on orthopedic OR efficiency. Although the mean delay of an operation's starting time during the peak-restrictions period was significantly different compared with the pre-COVID-19 and post-peak-restrictions periods ($P < .001$), the absolute magnitude of this delay was essentially negligible (mean delay of 8 minutes during the peak-restrictions period compared with a mean delay of 7 minutes before and after this period) (Table 1). Interestingly, the relationship of adjusted first-start delay between December 2019 and October 2021 appears to be temporally associated with the COVID-19 burden experienced by our hospital (Figure 1).

The absence of a delay in start time during the first wave of the pandemic is not consistent with previous studies examining orthopedic OR efficiency in Italy and the United Kingdom.^{9,10} These studies found that operations during the peak COVID-19 era had significantly delayed start times, with much larger magnitudes of delay. For example, orthopedic operations

TABLE 2. Turnover Time Analysis

Characteristic	Pre-COVID-19 (n = 1236)	Peak restrictions (n = 857)	Post-peak restrictions (n = 7850)	P
Turnover time, mean (SD) minutes	62 (49)	66 (51)	64 (51)	.002
Turnover time > 90 min, mean (SD) minutes	149 (86)	152 (85)	151 (82)	.67
Cases with turnover time > 90 min, n (%)	161 (13%)	130 (15%)	1177 (15%)	.18

FIGURE 2. Adjusted Turnover Time in Operating Room Efficiency Relative to COVID-19 Census



performed at the Galeazzi Orthopedic Institute, a high-volume private hospital in Milan, Italy, were delayed during April 2020 compared with April 2019; however, the mean delay during the examined time frame in 2020 was more than 2.5 hours.⁹ Similarly, the surgical preparation time for trauma and clinically urgent orthopedic surgeries performed in Cardiff and Vale University Health Board, in Wales, United Kingdom, was significantly longer in May 2020 (approximately 27 minutes) compared with May 2019 (approximately 15 minutes) ($P < .001$).¹⁰

In addition to investigating prolonged first-case start delays, we examined the impact of the COVID-19 pandemic on the turnover time between orthopedic operations. Our center experienced minimal change to turnover time during peak restrictions and afterward. In fact, after peak restrictions, we experienced a higher proportion of cases starting early. This finding is not reflective of the data found in previous studies from Italy and the United Kingdom. The Italian group found that mean turnover time increased from approximately 21 minutes in April 2019 to approximately 53 minutes in April 2020.⁹ Similarly, the research group from the United Kingdom found that the mean turnaround time significantly increased from approximately 16 minutes in May 2019 to approximately 48 minutes in May 2020 ($P < .001$).¹⁰

Several factors were expected to reduce the efficiency of the OR. One such factor was the increased time required for the donning and doffing of additional PPE necessitated by the pandemic.⁴ Similarly, increased anti-infective measures and sterilization precautions were expected to contribute to decreased efficiency.¹¹ Furthermore, we expected that positive or suspected SARS-CoV-2 infections would cause last-minute alterations in OR staffing that would lead to decreased OR efficiency.

However, the results of this study reveal that the overall decrease in orthopedic OR efficiency at our academic institution during the COVID-19 pandemic was not clinically significant. These findings suggest that the protocols put into place at our institution were effective in preserving orthopedic OR efficiency even in the face of a rapidly increasing COVID-19 caseload. These protocols included preoperative testing, deferment of nonurgent surgeries, and a thoughtful evaluation of anesthesia strategies.

Institutional protocols for testing patients prior to surgery were adjusted throughout the course of the pandemic, contingent upon vaccination status and type of procedure. Prior to the widespread availability of vaccines, all patients were mandated to undergo a polymerase chain reaction SARS-CoV-2 test within 48 to 72 hours before their scheduled surgery. In the case of urgent procedures for which testing was not feasible, patients were considered “presumed positive,” necessitating all health care workers involved in the case to wear protective gear, including gowns, gloves, surgical masks, and eye protection. Preoperative testing likely played a role in preserving OR efficiency, as it prevented cancellations of cases due to a lack of test results, ultimately leading to a more efficient allocation of staff resources. After vaccines became widely available, the preoperative testing requirements were relaxed and only

nonvaccinated and severely immunocompromised patients were required to undergo testing prior to procedures.

Moreover, our institution implemented protocols aimed at ensuring the safety of health care workers, which helped prevent infections and mitigate staffing shortages, both of which would have further affected OR efficiency. One such protocol required that only anesthesia team members be present in the OR during intubation and extubation. Additionally, following the release of CDC guidelines recommending deferment of elective procedures, our institution suspended all elective surgeries from March 18 to April 24, 2020, in an effort to conserve beds and PPE. This decision reduced not only the total caseload but also potential transmission opportunities. The successful implementation of these protocols explains why our institution was able to maintain OR efficiency throughout the COVID-19 pandemic.

Additionally, the period selected as a baseline for comparison in our study is likely to be a major driver of the discrepancy in the magnitude of the differences observed at our academic institution compared with that of previous studies. Past work has compared the peak of the COVID-19 pandemic with the corresponding time period in the previous year. Such comparisons assess the effects of protocols established for COVID-19 with the previous “normal” protocols that were in place before the pandemic, serving to highlight the driving factors described above. However, such approaches fail to examine the temporal relationship between increasing COVID-19 case burden and OR efficiency, whereas OR protocols are held as an essentially constant variable.

In contrast, our study compared the periods directly preceding, during, and immediately following the start of the COVID-19 public health emergency declaration in Tennessee. Because the same heightened protocols were in place across the latter 2 periods, such a comparison allows for the investigation of changes in OR efficiency directly caused by the increasing COVID-19 case burden rather than those caused by drastic alterations in hospital protocols. Such changes include increasing likelihood of staff testing positive for COVID-19 as the local case burden started to increase. Furthermore, such a selection may lend insight into changes in efficiency caused by evolving levels of stress and burnout experienced by surgeons, anesthesiologists, and other hospital staff members over the course of a spike in cases.¹²

Limitations

Although this study provides novel insight into the effects of the COVID-19 case burden on orthopedic OR efficiency, it is not without limitations. We selected the investigated time periods to minimize efficiency differences caused by changes in COVID-19 safety protocols; standards were consistently evolving and may have inadvertently confounded OR efficiency. Furthermore, we were unable to address potential variation in case mixture (eg, elective vs emergency) across the different time periods. Additionally, our analysis did not consider hospital capacity. Finally, all data were collected retrospectively and analyzed only for a single, large, academic medical center. Future studies should seek to validate

these findings across multiple hospital systems, with consideration of variations in case mixture and fluctuating hospital capacity.

CONCLUSIONS

The COVID-19 pandemic has had major impacts on the efficiency of orthopedic OR processes at hospitals around the world. Other centers have demonstrated dramatically decreased OR efficiency compared with previous years, likely due to major changes in protocols necessitated by the pandemic. Here, we show there was no clinically significant change in orthopedic OR efficiency at a single large teaching hospital during the start of the pandemic compared with the period directly preceding and following the original spike in SARS-CoV-2 cases. These results suggest that the protocols put into place at our academic institution were appropriate for maintaining orthopedic OR efficiency even in the context of a rapidly increasing COVID-19 case burden. ■

Author Affiliations: Vanderbilt University School of Medicine (SWK, SC, CA), Nashville, TN; Department of Orthopaedic Surgery (JMY), Department of Neurological Surgery (DCL, RD, BFS), Department of Anesthesiology (VT), and Department of Biomedical Informatics (VT), Vanderbilt University Medical Center, Nashville, TN; Owen Graduate School of Management (VT), Vanderbilt University, Nashville, TN.

Source of Funding: None.

Author Disclosures: The authors report no relationship or financial interest with any entity that would pose a conflict of interest with the subject matter of this article.

Authorship Information: Concept and design (SWK, SC, CA, JMY, DCL, RD, BFS); acquisition of data (SWK, SC, CA, JMY, DCL, VT, BFS); analysis and interpretation of data (SWK, SC, CA, JMY, DCL, RD, VT, BFS); drafting of the manuscript (SWK, SC, CA, JMY, DCL, BFS); critical revision of the manuscript for important intellectual content

(SWK, SC, CA, JMY, DCL, RD, VT, BFS); statistical analysis (SWK, SC, CA, DCL, BFS); provision of patients or study materials (SWK, SC, CA, JMY, DCL, BFS); obtaining funding (SWK, SC, CA, DCL, BFS); administrative, technical, or logistic support (SWK, SC, CA, JMY, DCL, BFS); and supervision (SWK, SC, CA, JMY, DCL, RD, BFS).

Address Correspondence to: Stephen Chenard, MSc, Vanderbilt University School of Medicine, 2209 Garland Ave, Nashville, TN 37232. Email: stephen.w.chenard@vanderbilt.edu.

REFERENCES

- Rodrigues-Pinto R, Sousa R, Oliveira A. Preparing to perform trauma and orthopaedic surgery on patients with COVID-19. *J Bone Joint Surg Am.* 2020;102(11):946-950. doi:10.2106/jbjs.20.00454
- Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. *Lancet Infect Dis.* 2020;20(5):533-534. doi:10.1016/s1473-3099(20)30120-1
- Non-emergent, elective medical services, and treatment recommendations. CMS. April 7, 2020. Accessed January 26, 2022. <https://www.cms.gov/files/document/cms-non-emergent-elective-medical-recommendations.pdf>
- Mattingly AS, Rose L, Eddington HS, et al. Trends in US surgical procedures and health care system response to policies curtailing elective surgical operations during the COVID-19 pandemic. *JAMA Netw Open.* 2021;4(12):e2138038. doi:10.1001/jamanetworkopen.2021.38038
- Joint statement: roadmap for resuming elective surgery after COVID-19 pandemic. News release. American Society of Anesthesiologists. April 17, 2020. Accessed January 26, 2022. <https://www.asahq.org/about-asahq/newsroom/news-releases/2020/04/joint-statement-on-elective-surgery-after-covid-19-pandemic>
- Rothstein DH, Raval MV. Operating room efficiency. *Semin Pediatr Surg.* 2018;27(2):79-85. doi:10.1053/j.sempedsurg.2018.02.004
- Forrester JD, Nassar AK, Maggio PM, Hawn MT. Precautions for operating room team members during the COVID-19 pandemic. *J Am Coll Surg.* 2020;230(6):1098-1101. doi:10.1016/j.jamcollsurg.2020.03.030
- Ti LK, Ang LS, Foong TW, Ng BSW. What we do when a COVID-19 patient needs an operation: operating room preparation and guidance. *Can J Anaesth.* 2020;67(6):756-758. doi:10.1007/s12630-020-01617-4
- Andreata M, Faraldi M, Bucci E, Lombardi G, Zagra L. Operating room efficiency and timing during coronavirus disease 2019 outbreak in a referral orthopaedic hospital in Northern Italy. *Int Orthop.* 2020;44(12):2499-2504. doi:10.1007/s00264-020-04772-x
- Mercer ST, Agarwal R, Dayananda KSS, Yasin T, Trickett RW. A comparative study looking at trauma and orthopaedic operating efficiency in the COVID-19 era. *Perioper Care Oper Room Manag.* 2020;21:100142. doi:10.1016/j.pcorrm.2020.100142
- Zeng H, Li G, Weng J, et al. The strategies of perioperative management in orthopedic department during the pandemic of COVID-19. *J Orthop Surg Res.* 2020;15(1):474. doi:10.1186/s13018-020-01978-y
- Coto J, Restrepo A, Cejas I, Prentiss S. The impact of COVID-19 on allied health professions. *PLoS One.* 2020;15(10):e0241328. doi:10.1371/journal.pone.0241328

Visit ajmc.com/link/89460 to download PDF