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

INTRODUCTION

The SARS-CoV-2 (COVID-19) virus emerged in Wuhan, China, on November 17, 2019. Similar to MERS-CoV and SARS-CoV, COVID-19 has been described to have its origins in bats, and many of the early patient cases were linked to a seafood and live animal market. The first confirmed case of COVID-19 in the United States occurred in Washington state on January 21, 2020. On March 1, New York City had its first case of COVID-19 in a 39-year-old woman who had recently traveled from Iran. By April 23, this number had blossomed to 142,432 confirmed cases and 10,977 deaths associated with COVID-19 in New York City alone. These figures are paralleled to the 849,094 cases, and 47,684 deaths recorded for the United States in total on the same day. New York City’s dense population of 8.34 million residents, many of whom are immigrants with multiple generational households, work in “essential jobs,” and are dependent on mass transit for travel, has made containment of the virus a difficult challenge.

Governor Andrew Cuomo declared a state of emergency in New York State on March 7. By March 12, recommendations were starting to appear against attending large gatherings and planned events of 500 people or more were cancelled. New York City schools were closed on March 16 for the remainder of the school year. On March 20, Governor Cuomo enacted the Policies Assure Uniform Safety for Everyone or PAUSE executive order in an effort to combat spread of COVID-19. This mandate closed all nonessential businesses statewide, cancelled individual gatherings of any size, recommended limiting use of public transportation, and instructed individuals to remain at least 6 feet from others when outside, which has colloquially been termed “social distancing.” Community members who had been caught violating the “social distancing” protocols would receive a fine of $500. This fine would later be increased to $1000 on April 6. At the time PAUSE was enacted, New York State had been facing a 71%–74% increase in cases daily. Queens, New York, was published as having the most reported cases of COVID-19 in New York City and the United States in mid-April (April 18: Queens, New York: 39,856; State of New York: 233,570; State of California: 28963; State of Pennsylvania: 31070).

Jamaica Hospital Medical Center (JHMC), established in 1891, is a 408-bed nonprofit teaching hospital located in Jamaica, Queens. The hospital is a New York State Designated Level One Trauma Center facility for New York City. The Orthopedic Surgery Department at JHMC comprised 3 trauma fellowship-trained attendings and supplemented by 3 additional attendings with fellowship training outside of traumatology. The New York University (NYU) Langone Health Orthopedic Surgery residency program staffs the orthopedic surgery service at Jamaica Hospital Medical Center with 2 postgraduate year (PGY)-5, 1 PGY-3, 2 PGY-3, and 1 PGY-1 residents. This normal resident team structure was supplemented with one additional PGY-3 resident during COVID-19 pandemic. A physician assistant also works with the resident physicians throughout the day to manage inpatient floor responsibilities. The PGY-2 and PGY-3 residents rotate 24-hour in-house call and staff consults. Each resident physician of the team participates in operative cases and cares for inpatients as well as outpatients in the onsite clinic under attending supervision.
Clinical Dilemma

The surge of COVID-19 infections in New York City led to a mass influx of patients into the already busy hospital systems of the metropolitan area. By the end of the first week, there were 76 confirmed cases of COVID-19 in New York State. By the end of the second week, it was 613 cases (806.6% increase); by week 3, it was 10,356 cases (1689.4% increase); and by the end of week 4, it had swelled to 52,318 cases (505.2% increase). As the crisis continued, physicians who were on the front lines caring for this population themselves became infected, driving the shortage of health care professionals needed to care for this increase in patient volume.

Physician shortages were well-documented in countries previously hit by the virus. COVID-19 arrived in Italy on January 31. By March 30, 11,591 deaths had been attributed to the COVID-19 in the country, with physicians representing 61 of these deaths. Facing a need for additional physicians, Italy allowed 10,000 senior medical students to skip their final examinations and enter the workforce early in the most hard-hit regions. Seasoned physicians were similarly drafted outside of their specialties to the front lines in medical wards and intensive care units. Although Italy was referenced early in the outbreak as a model for the expected infection patterns in New York State, New York State officially passed Italy on April 7 with 138,836 cases to 135,586 cases, respectively.

However, many of the personnel shortages seen in Italy have also held true for New York State. As attendings, residents, nurses, and other hospital personnel have cared for patients, they themselves have become infected and have been forced to quarantine, leading to a shortage of health care professionals.

Multiple measures have been initiated to meet this ongoing demand for health care professionals and medical facilities. Physicians have returned out of retirement and traveled from their home cities to New York in an effort to relieve the clinical burden on the area. On March 17, JHMC increased its hospital capacity by 150% by opening up unused wards, turning specialty wards into COVID-19 wards (e.g., pediatric ward converted to COVID-19 ward), and deploying outdoor open-ward tents. On March 30, the United States Naval Ship Comfort arrived in New York City to add about 1000 additional hospital beds to the City’s armament. On April 1, the Army Corps of Engineers completed its conversion of the 840,000 square foot Jacob K. Javits Convention Center into an alternate care facility equipped to care for 2000 patients. On April 3, 52 students at NYU Grossman School of Medicine graduated early to join the medical wards, intensive care units, and emergency departments at NYU Langone Health. Despite these milestone achievements, several physician deaths due to COVID-19 in the area have acted as reminders about the dangers to health care professionals working in these clinical environments.

Jamaica Hospital Medical Center’s response to COVID-19 has been challenged by its own health care professionals developing COVID-19 infections. As of March 31, the New York State Department of Health mandated that health care personnel with confirmed or suspected COVID-19 infection quarantines themselves for 7 days after illness onset and remains fever-free for at least 72 hours before returning to work. Asymptomatic but tested positive health care personnel must also quarantine for at least 7 days from the date of the test. After returning to work, these personnel were expected to wear a facemask for at least 14 days after symptoms onset. Given these instructions to limit COVID-19 transmission, the loss of 1 or 2 resident physicians to home quarantine could have been considered a hardship for any hospital department. Missing over 10 resident physicians would have been a disaster. Indeed, by March 24, 17 (24%) of the 72 resident physicians in the Internal Medicine department at JHMC were on home quarantine from COVID-19.

Because of this personnel shortage, hospital leadership began soliciting other departments for assistance with caring for the surge in patients infected with COVID-19.

The JHMC Orthopedic Surgery department was in a unique position to alleviate the physician shortage during the COVID-19 pandemic. Because elective cases had been postponed to limit patient exposure to COVID-19 and a lower volume of patients with traumatic musculoskeletal injuries were presenting to the hospital, likely secondary to the Governor’s recommendations for people to remain home, the Orthopedic Surgery department had the resources and flexibility to be repurposed into other roles at JHMC. One option was that an Orthopedic Surgery attending could staff musculoskeletal issues presenting to the emergency department to free up emergency department physicians to care for other patients. However, in most cases, these patients were already being evaluated by a physician assistant and either being redirected to clinic at a later date for nonurgent complaints or the orthopedic surgery resident on call was being consulted for assistance with any fractures or urgent complaints. A second option was that the Orthopedic Surgery department could begin conducting in-person or telehealth visits for patients with chronic medical conditions and assist with symptom evaluation or medication refills. This plan would allow the internal medicine and family medicine physicians to transition to solely inpatient care for COVID-19 patients. However, further discussions revealed that the orthopedic surgery physicians would not have the available staff to relieve all the clinics, and it would not be efficient to filter out the patients with more straightforward issues. Finally, the department could assume the responsibility of inpatient evaluation, treatment, and disposition of COVID-19 patients. These patients could be easily incorporated into morning rounds with the orthopedic surgery team, and because each patient had a similar chief complaint, their care could follow algorithm-based medicine. Furthermore, any emergency with a COVID-19 patient could be addressed by an orthopedic surgery team member as both the COVID-19 patients and musculoskeletal injury patients were located in the same hospital building. The Orthopedic Surgery department adopted care for 15 inpatients (with an expected maximum of 20 patients) undergoing treatment for infection with COVID-19 on April 4.

Management Solution

Several key principles were important to the successful partnership created between the Internal Medicine and
Orthopedic Surgery departments. The orthopedic surgery team was kept intact to allow for an efficient workflow in caring for both orthopedic surgery patients and internal medicine patients. Furthermore, keeping the team together built camaraderie and limited disturbances to the familiar culture that would have occurred if unfamiliar team members had been introduced or if orthopedic surgery residents had been removed to other services. Maintaining the orthopedic surgery team structure allowed for continuation of a well-understood hierarchical chain of command that maximized efficiency and safety. The team has been able to maintain safety and prevent infection of members of the team through a team-based approach of monitoring the donning and doffing of personal protect equipment (PPE) as well as the appropriate use of the PPE (disposable gown and gloves, N95 mask, and face shield). Cross-contamination between the multiple hospitals within the NYU Langone Health-affiliated network was limited by keeping the orthopedic surgery team members solely at JHMC and recommending against contact with resident physicians at other hospitals. Residents continued their orthopedic educational experience through residency-wide educational conferences held over video conferences with the team calling-in from the JHMC orthopedic surgery workroom.

Because the purpose of the system was to offload the burden of COVID-19 on the medicine teams, patients were triaged based on severity. Severity was determined by the medicine team when they accepted patients from the emergency department. Criteria for each level of severity are listed in Table 1. Most patients who were assigned to the Ortho-COVID-19 management team were patients in the mild to moderate severity class. Most patients were stable but still required oxygen weaning for safe discharge. Incorporating orthopedic surgery into this role allowed for the pure internal medicine teams to focus on unstable and critical patients.

Oxygen therapy escalation was guided by hospital-wide policies. While continuously evolving, the general progression for increasing oxygen requirements was from nasal cannula to venturi mask, to nonrebreather mask, to high-flow nasal cannula, to BiPAP and finally intubation. Patient oxygen saturations were consistently monitored and if a patient had an oxygen saturation less than 92% on the maximum level of the given oxygen supplementation device, then he or she was escalated to the next level of oxygen supplementation. With the understanding that little is known about optimal antibiotic and antiviral therapy for treating COVID-19, the hospital-wide policy was to start patients on hydroxychloroquine with azithromycin or doxycycline and daily EKGs. Any concerns of QTc prolongation resulted in patients being switched to darunavir-cobicistat combination pills and PEG interferon. Any pharmacologic escalation was made with input from infectious disease consults. The infectious disease consults were managed by the same team that routinely cares for orthopedic patients with infectious processes.

The Ortho-COVID-19 team was structured to allow for efficiency while maintaining adequate oversight and accountability. A family medicine or internal medicine attending was at the top of the hierarchy and acted as the point of contact if the orthopedic surgery team encountered complex medical questions (Fig. 1). Each rounding team functioned with an orthopedic surgery attending at its head to split the floor of up to 20 patients. The goals of the rounding teams were to evaluate patients for any acute issues, identify patients with worsening clinical status to escalate oxygen requirement, and wean oxygen supplementation in stable patients to move these individuals closer to discharge from the hospital. Because oxygen adjustments often required several minutes of monitoring with a pulse oximeter to ensure that the algorithm policies were being met, members of the rounding team were assigned specific roles to expedite morning rounds in what we have termed the “Agriculture Model”:

1. Sower: a junior resident who would work several rooms ahead of the “reaper team” with a portable pulse oximeter and record the current oxygen supplementation level and oxygen saturation on the patient’s board. They would then begin the oxygen requirement challenge by turning down the patient’s oxygen flow rate, ensure that no rapid decompensation would occur, mark the new oxygen flow rate on the patient’s white board, then move on to the next patient’s room (Figs. 2 and 3A, D).

2. Reaper team: a chief resident along with a junior resident who would follow the “sower” by a few minutes to recheck the new oxygen saturation and titrate the oxygen

| TABLE 1. Jamaica Hospital Medical Center Criteria for Illness Severity Triage |
|---------------------------------------------------------------|
| **Mild Disease** | **Moderate Disease** | **Severe Disease** | **Critical Disease** |
| Mild clinical symptoms: | Fever (with symptoms) | RR >30 breaths/min | Mechanical ventilation |
| Cough | Worsening symptoms | HR >120 BPM | Shock |
| Mild fever | Within days | O2 sat. <93% | Multiorgan failure |
| Dyspnea | Progression of symptoms | Within 24 h | |
| Rhinitis/pharyngitis | | | |
| GI symptoms | | | |
| Oxygen saturation >94% | | | |
| Imaging (if done) negative | Imaging positive | Worsening of chest imaging within 24–48 h | Worsening of chest imaging within 24–48 h |
| Mild or moderate disease—non-ICU care | | Severe or critical disease—ICU care | |
requirement up as needed. Upon confirming that a patient’s oxygen levels had stabilized, these team members would report to the “farm” (Figs. 3B, D).

3. Farm: a junior resident (Farmer) with a portable electronic medical record workstation [computer-on-wheels (COW)] that remained outside of patients’ rooms. This resident would record new oxygen requirements for patients, make any notable updates, and write the progress note (Figs. 3C, D).

Upon completion of rounds, a junior resident would work with the physician assistant on the orthopedic surgery team to address any concerns that arose during rounds. The creation of these roles ensured that COVID-19 patients were evaluated by multiple team members to deliver safe and effective care while still fulfilling the responsibilities of the Orthopedic Surgery department.

Workflow Considerations

Necessary adjustments were made to the normal day-to-day workflow to accommodate the additional time needed for managing both an orthopedic surgery service and an internal medicine service. Orthopedic consults from the past 24 hours were reviewed as a team in the workroom at 6:15 AM (Table 2). The on-call orthopedic surgery resident then received sign-out from the overnight internal medicine physicians at 7:00 AM. Next, the on-call orthopedic surgery resident updated the remainder of the orthopedic surgery team, and walking rounds were conducted in a regimented fashion starting at 7:30 AM. Orthopedic surgery patients without an active COVID-19 infection were seen first, followed by orthopedic surgery patients with a COVID-19 infection, and internal medicine rounds on the COVID-19 isolation wards were completed last. This rounding order was completed to prevent any possible spread of the virus from COVID-19–positive patients to COVID-19–negative patients. After rounds were completed, the team reconvened in the workroom to review each of the patients and confirm assigned tasks. To accommodate the increased number of patients on morning rounds, operating room start times were pushed back 1 hour to 8:30 AM. The orthopedic surgery team averaged at least 2 trauma cases per day during the pandemic. COVID-19 patients were signed out to the night-coverage internal medicine teams at 7:00 PM to allow the orthopedic surgery 24-hour call resident to focus on orthopedic consults and management of the inpatient orthopedic service.

Most COVID-19 patients on the Ortho-COVID-19 service were clinically stable. After rounding as a team in the morning, the COVID-19 patients were discussed with the family medicine or internal medicine attending to identify patients requiring close monitoring. Similarly, any patients with progressively complex medications were re-evaluated by the head medical attending in the morning with escalation of care as necessary. As an example, one of our COVID-19 patients suffered deterioration of his mental status over several days with a rapid drop in hemoglobin levels and increasing supplemental oxygenation requirements (Hospital day 5, hemoglobin 8.8 g/dL, oxygen saturation 84% on max flow using nonrebreather mask). Frequent and direct conversations about this patient were held with the family medicine attending and the family medicine attending facilitated his transfer to an intensive care unit. This constant line of communication ensured appropriate care for the COVID-19 patients covered by orthopedic surgery.

Availability and use of PPE were essential to prevent team members from contracting COVID-19. To meet this goal, maintaining a constant stock of PPE was a team effort. Each morning, the overnight consult resident would collect a set of fresh PPE for the entire team from the JHMC storeroom. Team members were provided with an extrasurgical mask, gowns, protective eye equipment, head protection, and gloves in the call room before rounds would start. PPE was donned in the call room together as a team. As N95 masks were in short supply, each team member received new N95 masks at the beginning of each week, which they would keep in a brown paper bag when not being actively used. The attending and chief residents confirmed that each member of the team had proper PPE in place before leaving the room to

FIGURE 1. Operational hierarchy for the Ortho-COVID-19 management team.

FIGURE 2. Example of a patient’s whiteboard with pertinent oxygen saturation and delivery mechanism recorded by Sower member.
round. Between each patient contact, members of the team would double glove and replace the outer glove before coming in contact with the next patient. Hand sanitizer was applied to the inner glove before application of the second layer glove. Doffing of PPE would occur after medicine rounds concluded and would be performed at the exit of the COVID isolation unit. Gowns, outer surgical masks, face shields, gloves, and head gear were discarded before returning to the workroom.

DISCUSSION

The COVID-19 pandemic has placed health care professionals in an uncomfortable and stressful work environment. To appropriately care for the influx of patients with COVID-19–related illnesses, physicians trained in surgical subspecialties have been drafted to internal medicine floors and have been asked to relearn skills outside of their traditional scope of practice. Our own experience as orthopedic surgery attendings and resident physicians has demonstrated that the “Agriculture Model” is an efficient and safe technique for treating COVID-19 patients while still sustaining a fully functional orthopedic surgery service. Maintaining the orthopedic surgery team as a complete unit during the pandemic was a tenet of our success.

Parallels can be drawn between the psychological factors necessary for success in the Ortho-COVID-19 team and a military unit. The Department of Defense has long understood the importance of psychological resilience among its service members. Meredith et al conducted a systemic review of 270 publications identifying realism, behavioral control, positive command climate, teamwork, cohesion, and collective efficacy as examples of 20 individual-level, family-level, unit-level, and community-level factors constituting resilience. Group cohesion has especially been long-considered important to the success of a military group. A high level of group cohesion allows the unit the best chance of survival and improves performance. Changes in organizational structure and disturbing social relationships decreases team cohesion and can lead to lapses in safety and efficiency. Keeping the orthopedic surgery team as a single unit for both orthopedic and COVID-19 care allowed the team practice, these techniques maintain resilience despite working in a new environment.

Residency is a balance between service and education. One concern about adopting additional internal medicine patients onto an orthopedic surgery service was that these patients would take away time from orthopedic surgery didactics. In our experience, this concern was not an issue. In contrast to residents removed to other services, the orthopedic surgery residents continued to progress in their orthopedic training by seeing orthopedic surgery patients in clinic, triaging orthopedic surgery consults, and preparing for the urgent or emergent orthopedic surgery cases. These “hands-on” learning opportunities were supplemented by weekly video-assisted residency-wide lectures and team-based fracture conferences.
Time constraints between the operating room and floor work were a second concern when developing the Ortho-COVID-19 service. Although the internal medicine teams required assistance with managing the COVID-19 patients, the Orthopedic Surgery department was still expected to manage patients arriving to the hospital with emergent musculoskeletal injuries. We believe that developing our workflow around efficient and safe patient care allowed us to achieve this goal. Through the aforementioned daily rounding plans, we were able to reach the operating rooms by 8:30 AM and complete at least 2 emergent orthopedic cases per day. On many days, not completing more than 2 cases was due primarily to the limited number of patients presenting to the hospital with musculoskeletal injuries rather than personnel or time constraints. Incorporating COVID-19 patients into our care was a manageable endeavor for our orthopedic surgery service.

Although no 2 residency programs are similar with regard to the number of available residents, site-specific needs, or patient volume, we recommend maintaining the integrity of orthopedic surgery teams during the COVID-19 pandemic and future disasters. Identifying methods for incorporating patients normally destined for an internal medicine service onto an orthopedic surgery team in environments hampered by health care personnel shortages allows for better patient care, improved resident physician morale, and a more cohesive team structure while allowing for the continued orthopedic education and service.

CONCLUSIONS
The exponential increase in patients requiring hospital-based care caused by the COVID-19 pandemic has required surgical subspecialists to rapidly adapt to working outside of their scope of practice. At Jamaica Hospital Medical Center, the Orthopedic Surgery department has successfully incorporated stable COVID-19 patients on their service, freeing internal medicine physicians to manage and treat critically ill patients. Our method’s success hinged on the group cohesion and efficiency wrought from maintaining the integrity of our team. We presented our model as an example for other surgical subspecialties caring for COVID-19 patients during this pandemic or future health care crises.

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