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Perspective

Addressing a national crisis: the spine hospital and department's response to the COVID-19 pandemic in New York City

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Abstract

In a very brief period, the COVID-19 pandemic has swept across the planet leaving governments, societies, and healthcare systems unprepared and under-resourced. New York City now represents the global viral epicenter with roughly one-third of all mortalities in the United States. To date, our hospital has treated thousands of COVID-19 positive patients and sits at the forefront of the United States response to this pandemic. The goal of this paper is to share the lessons learned by our spine division during a crisis when hospital resources and personnel are stretched thin. Such experiences include management of elective and emergent cases, outpatient clinics, physician redeployment, and general health and wellness. As peak infections spread across the United States, we hope this article will serve as a resource for other spine departments on how to manage patient care and healthcare worker deployment during the COVID-19 crisis. © 2020 Elsevier Inc. All rights reserved.

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Although from an early age I had learned from Charles Darwin and others that species adapt naturally to their environment, in the moment, that adaptation is often a painful process. The onset of COVID-19 and the changes forced upon us by science, common sense, and our survival instinct have been a strong reminder of the challenges true adaptation involves.

This spring's events have felt familiar to me – I had already lived a similar experience. In the first weeks after

taking command of Joint Special Operations Command (JSOC), it became apparent we were losing the battle to Al Qaeda in Iraq (AQI). JSOC, America's elite counter-terrorist task force, was built to operate in small teams conducting elegant, but infrequent, precise strikes. We were the most efficient and effective counter terrorism force in existence – but we were not adaptable. We'd never really had to be.

AQI however, changed the rules by morphing faster than our slow, but precise, operations could counter. A target, or

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Foreword: By Stan A. McChrystal, General, US Army (Retired).

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fleeting opportunity, that was located in the morning was typically gone by evening. Against an enemy that operated differently than anything we had seen before, we had to change. Unsure of what the right answer was, we started from the reality that the one course of action for which we had reliable data, the status quo, was failing. So, we adopted a policy of “question how we do everything.” Nothing was held sacred – we needed to find out what worked to defeat AQI and we needed to do it quickly. It was disconcertingly disruptive for a force inclined to developing and then refining to near perfection our tactics, but it worked. We iterated adaptations until JSOC became instinctively flexible and wickedly fast.

The reality for most organizations is that they do not adapt until they are forced to do so. What is often touted as a leader’s foresight or vision was really driven by the reality of a burning platform – change or grow irrelevant; adapt or die.

For America’s healthcare teams, the fight against COVID-19 is not just the search for a vaccine or management of ventilators. It is adapting every aspect of managing the care of patients. Leveraging virtual interaction, mining growing bodies of data, and realizing that not all care will wait until we return to status quo ante – it has to continue on now, but safely. And it must be delivered by healthcare professionals who are performing the extraordinarily complex tasks they always have, but now in the vastly more difficult COVID-19 environment.

All this is doable, because it has to be. It is also possible because the patient-centric mindset that drives the people who have chosen to care for others will drive it. It is not easy and would not get much easier – but it is working and will only get better.

Background

On December 31st, 2019, local health officials in the Chinese province of Hubei reported 41 cases of a mysterious pneumonia to the World Health Organization (WHO) [1]. While viral pneumonias are commonplace, this cluster was particularly unusual in that a high percentage of patients was responding poorly to typical supportive measures and becoming critically ill. It was soon recognized that this illness was being caused by a never-before-seen coronavirus subsequently named the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) with its infectious manifestation termed the coronavirus disease 2019 (COVID-19) [2,3]. The outbreak was reportedly centered on a wet market in the city of Wuhan, China, but quickly spread [4]. On January 20th, 2020, the first case of the novel coronavirus in the United States was reported in Snohomish County, Washington. By March 11th, the virus had spread to 30 different countries and sparked the WHO to declare a global pandemic [5]. At the time of this writing, there have been over 1 million confirmed cases of COVID-19 in the United States with nearly 59,000 deaths [6].

The speed and intensity with which the virus spread has left governments and healthcare systems unprepared, under-resourced and without enough personnel to adequately respond. Particularly hard hit has been New York City, which is now one of the global viral epicenters. As of April 28th, there were a staggering 17,682 mortalities in New York City alone, representing over 30% of all COVID-19-related deaths in the United States [6]. According to the University of Washington’s Institute for Health Metrics and Evaluation, the peak hospitalization rate in New York will occur during the second week of April, preceding the majority of the United States [7]. Our institution has been on the forefront of the COVID-19 pandemic, as we treated “patient zero” in New York City, who presented to our Emergency Department (ED) on February 28th. To date, we have treated over 5,000 COVID-19 positive inpatients in the epicenter of the viral pandemic with strained resources. Our experiences may serve as a model for other institutions to prepare as their regions approach peak infection. Therefore, the purpose of this paper was to describe our orthopedic departments’ approach toward (1) management of elective cases and outpatient visits, (2) management of “emergent” surgical cases, (3) redeployment of orthopedic personnel, and lastly (4) maintaining protection and well-being within the department.

Elective case and outpatient management

Published data by healthcare providers in Asia and Europe demonstrated that the most substantial threat to COVID-19 patient morbidity and mortality was the lack of adequate critical care resources including intensive care unit (ICU) beds and respiratory support [8,9]. Early reports from Lombardy, Italy, exposed the strain of widespread community transmission on hospital ICU capacity [10]. Hospitals across this northern Italian region had a combined pre-surge capacity of 720 ICU beds, of which COVID-19 positive patients filled 60% only 2 weeks after the first patient presented with symptoms. Overall projections for ICU requirements exceeded 14,000 beds, well beyond the region’s capacity. Similar projections began to take hold in New York State, where peak infection bed requirements could reach as high as 46,000 versus the 13,000 beds that were available presurge [7]. By the time the Surgeon General of the United States recommended a cancellation of all elective cases on March 14th, there were already 185 confirmed cases in New York City with widespread community transmission [11]. Recognizing the impending public health crisis, our institution decided to cancel all elective cases on March 13th. While this decision was difficult, it took into account four important factors: (1) preservation of adequate personal protective equipment (PPE) for healthcare workers including N95 and surgical masks, as well as gowns and gloves, (2) diversion of ventilators and anesthesia staff to address COVID-19 positive patients requiring ventilator support, (3) allocation of hospital operating rooms as

designated COVID-19 ICU beds, and (4) alleviation of overall staff shortage due to sickness, redeployment, and childcare needs.

Elective case management may differ based on environmental factors including local disease testing schema, quarantine protocols, and rates of community transmission, as well as hospital resources including available critical care beds, respiratory support and staff availability. While cancellation of elective cases has become common at viral epicenters throughout the world, including our own institution, this may not be necessary in regions where disease is less prevalent [8,10]. Multiple authors have proposed various protocols aimed at reducing elective case volume gradually to account for the rate of local infections and system resources. Burke et al. proposed a volume-limiting approach toward elective cases based on (1) number of infections in the community, (2) number of infections admitted to the hospital, and lastly (3) degree of staffing shortages [11]. Likewise, the American Academy of Orthopaedic Surgeons has published elective surgery guidelines that consider both patient and institutional variables [12]. (Fig. 1) In instances where continuation of elective cases is deemed appropriate, one must take into account various factors including type of surgery and patient demographics as they relate to inpatient bed utilization.

In instances where hospital resources are strained in the wake of mounting community viral infections, one can

consider an ambulatory surgical center as a viable option for some elective spine procedures. The Ambulatory Surgery Center Association released a consensus statement advocating for the use of ASC “to provide safe surgical care for patients whose condition cannot wait until hospitals return to normal operations” [13]. It should be noted that the Ambulatory Surgery Center Association does however recommend prioritizing hospital supply chains and coordination with local hospitals prior to considering outpatient surgery in ASCs. Over the course of the last decade, there has been a clear shift away from the inpatient hospital setting and toward the ASC when performing select spine cases. (Table 1) Idowu et al. performed a retrospective database review of all spine procedures from 2003 to 2014 looking for trends in outpatient and ASC utilization for spine surgery [14]. Over that time period, the rates of outpatient lumbar decompressive laminotomy rose from 18.7% to 68.5%. This was followed by posterior cervical decompression which rose from 0% to 46.7%. Best et al. demonstrated that anterior cervical discectomy and fusion accounted for 17% of all outpatient spine procedures in 2006 [15]. Another study observed a similar increase in popularity of outpatient lumbar procedures between 1994 and 2000 and noted that discectomy was the most common procedure, comprising 70% to 90% of all lumbar outpatient cases [16]. At our institution, we decided to halt all elective cases including those able to be performed at an ASC in order to

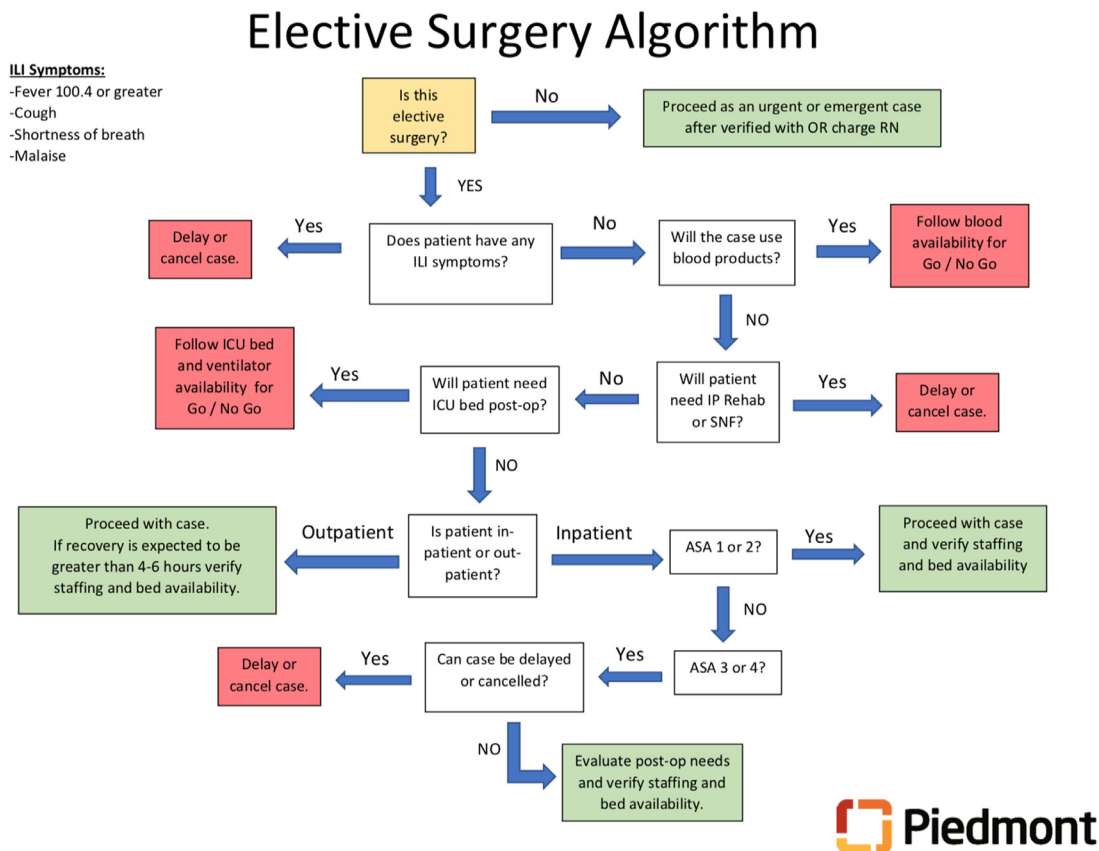


Fig. 1. American Academy of Orthopaedic Surgeons Elective Surgery Algorithm.

Table 1
List of commonly performed procedures in ASC

Common ASC spine procedures
Lumbar microdiscectomy
Lumbar laminectomy
Vertebroplasty
Kyphoplasty
Anterior cervical discectomy and fusion
Cervical foraminotomy
Cervical disc arthroplasty
Lumbar fusion
Posterior cervical fusion

divert available PPE and personnel to the COVID-19 designated centers, as well as protect the overall exposure risk to our surgeons, staff, and patients.

On March 17th, 2020 our department decided to cancel all outpatient office visits in an attempt to mitigate viral transmission. At that time, all visits were transitioned to a telemedicine model. On March 18th, the U.S. Department of Health and Human Services announced that physician medical licenses would be recognized across state lines. Additionally, the Centers for Medicare & Medicaid Services provided guidance on Medicare coverage and payment for telemedicine and virtual services [17]. These changes effectively paved the way for broader use of telemedicine during the COVID-19 pandemic. The efficacy of telemedicine has been well documented in various subspecialties including dermatology, allergy/immunology, infectious disease and even surgical specialties [18–21]. Precedent for the use of telemedicine has additionally been established in orthopedic surgery. Lambrecht et al. reflected on their experience of using telemedicine for 410 orthopedic consultations over the course of 2 years [22]. They reported average consultation times of 12.8 minutes with no reported complications including improper diagnosis or treatment plan. Buvik et al. performed a randomized control trial of 400 patients who were randomized to either an in-person consultation or a telemedicine consultation. Telemedicine visits were found to be noninferior with 98% of virtual visits rated as “good” or “very good” by surgeons [23]. The use of telemedicine in spine surgery has been less well defined. Pirris et al. published on a case series of pediatric neurosurgical patients who had wound complications following spinal surgery [24]. Through use of a cellular phone camera, their

team was able to monitor wound healing in all patients. At our institution, we have employed the use of telemedicine in both outpatient as well as inpatient settings. This includes conducting post-operative visits, new and established patient histories, as well as imaging review and discussion of care. Those patients who have been deemed to be potentially operative are prioritized for in person consultation upon lifting of social distancing restrictions. Inpatient and ED consults have typically been managed first through a telemedicine visit where the surgeon gathers pertinent patient history and, in select instances, physical exam maneuvers. This has minimized the time for in-person patient interaction and decreased the risk for viral transmission. While we recognize there are limitations to telemedicine in both volume and quality of visits, we strongly advocate for its use wherever possible during this global pandemic.

Urgent and emergent case management

There can be ambiguity when attempting to determine which surgical procedures are elective, urgent or emergent. Additionally, conflict may arise among healthcare providers when attempting to prioritize cases in the setting of severely limited personnel, resources, and ventilators. Therefore, our institution sought to create a 2-step process to determine both the urgency of cases and the order in which they should proceed. First, a directive was given to create clear guidelines for determining surgical urgency from both an institutional as well as a departmental/divisional standpoint. Those cases that met institutional and departmental criteria were then directed to an independent hospital panel that would determine their priority.

At the time all elective cases were cancelled, our institution published criteria for case escalation, which would serve as a basis for categorizing the urgency of cases across all sites. (Fig. 2) Emergent cases were classified as those that are life or limb-threatening and would require access to the operating room within 30 minutes. These cases would allow for “bumping” of any service into any available operating room when applicable. Urgent cases were defined as those requiring an operating room within eight hours and would allow for “bumping” within their surgical service (ie, orthopedics bumps orthopedics). Add-on cases were defined as those that should be performed within 24 to

Criteria For Escalation	
Emergent	Life threatening condition needing immediate access to the OR (within 30 minutes) for threat to life or limb (immediate entry, requires bumping, any available room).
Urgent	Requires an operating room within 8 hours , prioritized to clinical condition (requires bumping same service).
Add-On	Non-emergent case that needs to be done, once the urgent and emergent cases are completed. At MSCH, all Long Bone Fractures are classified as first priority. Requires an operating room within 24-48 hours .
To Consider	In-house patients that are discharge dependent on case being done.

Fig. 2. Institutional Classification of Case Urgency.

Phase II Curtail Elective Practice		Phase III Eliminate Elective Practice	
Schedule	Reschedule	Schedule	
Cervical Myelopathy	Low Back Pain	Progressive Neurologic Deficit (emergency)	
Acute Radiculopathy	Neck Pain	Epidural Abscess (emergency)	
Acute Compression Fracture	Flat Back Syndrome	Spine Trauma	
Discitis / Osteomyelitis	Scoliosis without Neurologic Deficit		
Proximal Junctional Kyphosis	Revision Surgery (in absence of new or progressive neurologic deficit)		
Scoliosis with neurologic deficit			

Fig. 3. American College of Surgeons guidelines for triage of orthopaedic patients.

48 hours, lending priority to long bone fractures. Lastly, the “to consider” classification was given to those patients whose cases were not time sensitive, but whose discharge from the hospital was pending surgical intervention. The institution published a sample list of cases across all specialties and where they fall into the criteria for escalation.

To date, there are no published articles detailing how to best allocate resources and prioritize urgent/emergent cases within a spine division during times of crisis. On April 3, 2020, Burke et al. published a letter in Neurosurgery describing a surge and treatment algorithm for neurosurgical patients during the COVID-19 crisis [11]. The American College of Surgeons (ACS) published a COVID-19 guideline on March 24th, which offers guidance on urgent or emergent surgical cases depending on the level of surge [25]. (Fig. 3) The American Academy of Orthopaedic Surgeons has referred to both the ACS guideline as well as the Johns Hopkins case triage list, which is inclusive of all orthopedic subspecialties [12]. The Congress of Neurological Surgeons and American Association of Neurological Surgeons likewise refer to the ACS guidelines for scheduling of urgent or emergent Neurosurgical cases. On April 3, the North American Spine Society published the most comprehensive, spine-specific guidelines for the triage of cases during the COVID-19 crisis [26]. (Fig. 4) In this algorithm, cases that are considered emergent are: progressive neurologic deficit due to compression, spinal instability, epidural abscess, and wound infections. In this time of peak infections, our department has adopted the North American Spine Society triage guidelines.

At our hospital, emergent cases that meet institutional and divisional criteria can proceed to the operating room. If a surgeon wishes to book an urgent case, he or she must complete the Surgical and Procedural Request Form. (Fig. 5) This one-page document seeks to clarify the urgency of the procedure, clinical background, patient prognosis, and resource utilization. Surgeons submit the Procedural Request Form to an independent panel known as the Surgical and Procedural Scheduling Committee for approval and prioritization. This panel comprises one surgeon, a nonoperative physician, an ethicist and lastly a member of the hospital executive board. All members of the panel remain anonymous to the public and employees of our institution. We have received many calls from colleagues across the country whose hospitals have established an intra-departmental committee to determine which cases are urgent or semi-emergent. Yet without anonymity, it is

impossible to remove personal interests from the decision-making, which may be at odds with key members of the team. When making decisions on the urgency and priority of cases, this committee takes into account guidelines from the CDC, WHO, New York State Department of Health and New York City Department of Health, as well as appropriate subspecialty academy guidelines. In an environment with limited hospital resources and personnel, this committee serves to remove the ethical and legal burden from surgeons while also serving the best interests of not only the patient but also the community as a whole. It is important to note that there are limitations to this system, which include review of cases by surgeons and/or lay people that is outside of their direct area of expertise.

Operating room protocol

Recently published literature has highlighted the increased risk of SARS-CoV-2 exposure to surgeons and surgical support staff. Guo et al. performed a survey study that identified 26 orthopedic surgeons who were positive for COVID-19 in Wuhan, China [27]. According to respondents, 12.5% of infections were attributed to the operating room, with the absence of N95 mask being an independent risk factor. Likewise, increased rates of exposure have been reported in other surgical subspecialties including oral surgery and endoscopy [28,29]. It is likely that surgeons and operative staff are at increased risk of exposure due to aerosolization of the virus during intubation. A recently published article demonstrated the stability of SARS-CoV-2 in aerosolized form for up to three hours [30]. It is not currently the standard of care for surgeons to be wearing N95 masks while operating, thus potentially exposing them to substantial risk in the period following intubation. With this understanding, the use of N95 masks and full-face shields has quickly become implemented into our operative PPE protocol. In an effort to protect both our patients as well as our staff, our institution has mandated that all patients be tested for COVID-19 with a nasal swab viral PCR when admitted to the hospital and prior to proceeding to the operating room.

Recognizing these potentially devastating risks to the operative team, our department developed a protocol in conjunction with the Department of Anesthesia that is designed to minimize exposure to aerosolized viral particles. We identified three distinct phases during the

Category	Clinical Considerations	Recommendation
Emergent	<ul style="list-style-type: none"> Progressive or severe neurologic deficit due to neurologic compression from any cause (eg, infection, tumor, fracture, disc herniation) Spinal instability at risk of causing neurologic injury from any cause (eg, fracture, tumor, infection) Epidural abscess requiring surgical decompression Postoperative wound infection 	Do not postpone the procedure/treatment
Urgent	<ul style="list-style-type: none"> Cervical or thoracic myelopathy due to spinal stenosis, with recent progression Spinal infection (eg, discitis, osteomyelitis, epidural abscess) that fails to respond to medical management Persistent significant neurologic deficit due to neurologic compression with or without deformity (distinguished from “severe neurologic deficit” that is listed under emergent) Spinal conditions causing intractable pain that result in ED presentation, severe functional limitations and/or excessive opioid use despite non-procedural attempts at management (eg, painful disc herniation, painful fracture, progressive fracture related deformity). 	Proceed with procedure/treatment if the local situation and resources allow (see above)
Elective	<ul style="list-style-type: none"> Spinal conditions where pain and dysfunction can be reasonably managed without procedural intervention during the crisis (eg, chronic conditions, degenerative spinal disorders such as degenerative disc disease, some disc herniations, spinal stenosis or spondylolisthesis without significant neurologic deficit) Scoliosis and/or kyphosis correction Symptomatic hardware or pseudoarthrosis 	Consider postponing the procedure/treatment

Fig. 4. North American Spine Society guidance on elective, urgent, emergent cases.

surgical episode where attention should be paid in order to limit transmission: (1) OR preparation, (2) intubation, and (3) extubation.

Preparation of the operating room

During this phase, one should remove all nonessential equipment from the operating room such as IV poles, IV pumps, rapid infusor systems, suture cart, etc. Medication and equipment expected to be needed during the case should be removed from the anesthesia cart and the drug-dispensing unit and placed on a clean, easily wipeable surface. One should close all drawers, cover the anesthesia cart and drug-dispensing unit with a plastic drape, and try to avoid accessing it during the case. One should have emergency medication and equipment nearby in a closed bag, so it is easily accessible if needed but does not get contaminated during the procedure. The anesthesia machine has to be protected with a HEPA filter.

Endotracheal intubation

With very few exceptions, most spine surgeries require endotracheal intubation. Operating rooms are a positive pressure environment. Therefore it is recommended that if a negative pressure room is available, the patient should be intubated there and then transported back to the operating room. If such a room is not available, the intubation will take place in the operating room. After preparation of the OR as detailed above, all nonessential personnel, including the surgical team, should leave the room. All anesthesia providers must wear PPE including N-95 masks, impermeable gowns, face shields or goggles, double gloves, shoes, and head covers. Additionally, a transparent drape should be placed over the patient's head, neck and shoulder area to contain the area of potential respiratory expectorants during induction. This drape can be removed after completion of the intubation process.

Surgical and Procedural Request Form Campus		
Patient Name:	MRN:	Diagnosis:
Surgery/Procedure:		Est. length of time:
Surgery or Procedure Is: Urgent <input type="checkbox"/> Semi-Urgent <input type="checkbox"/> <i>Urgent</i> -Surgery or procedure needed within 6-12 hours to prevent further deterioration or morbidity <i>Semi-Urgent</i> -Surgery or procedure could be done within 48 hours		
Clinical Summary (Overview of patient needs and rationale for scheduling the surgery or procedure, including impact of surgery on expected length of life and quality of life; have non-operative alternatives been explored or exhausted?; anticipated LOS) : 		
Would you be surprised if patient were deceased within a year? Please detail clinical resources that may be needed for this patient post-surgery or procedure. Check all that apply: <input type="checkbox"/> Ventilator <input type="checkbox"/> ICU Bed <input type="checkbox"/> Pt is currently inpatient <input type="checkbox"/> Pt is currently in a nursing facility <input type="checkbox"/> Other clinical specialized resources, ie perfusionists, neurophysiology techs, dialysis nurses(please specify): <input type="checkbox"/> Specialized equipment needed ie CPB, CRRT(please specify): <input type="checkbox"/> Post-op disposition to SNF or Rehab needed (please specify):		
Surgeon Name (Please print):		Contact Cell Number:
<input type="checkbox"/> please check here to verify you will be available when an OR is made available for this surgery or procedure.		
Surgeon Signature:		Date:

Fig. 5. Institutional surgical and procedural request form.

The patient should be preoxygenated for several minutes. A rapid-sequence induction to achieve optimal intubating conditions in the shortest possible time is the preferred method of induction. This avoids mask ventilation with highly aerosolizing potential.

A video-laryngoscope is preferred for intubations as it allows the anesthesia provider to keep greater distance from the patient’s oral cavity. The endotracheal tube (ETT) cuff should be inflated immediately, the ETT should be connected to the anesthesia circuit and ETCO2 confirmed. It is vital at this time to adequately secure the ETT. Although an endotracheal intubation is an aerosolizing procedure, an unsecured airway over the whole length of the surgery may have greater potential to create aerosolized viral particles than the intubation itself. For auscultation of breath sounds a disposable stethoscope should be used. Patients presenting for spine surgery, in particular surgery involving the cervical spine, frequently require other methods of securing the airway. In order to protect the patient from further injuries

to a potentially unstable cervical spine or in patients with an anatomically difficult airway, a fiber-optic or an awake fiber-optic intubation is often the only safe method of endotracheal intubation. These procedures carry a very high risk of contaminating the environment by respiratory expectorants and should be avoided if possible. If necessary, they should be performed in a negative pressure environment. Putting the patient in a prone position usually requires disconnection of the ETT from the circuit in order to minimize risk of ETT displacement. In these patients the anesthesia practitioner should carefully weigh the risk of ETT displacement versus aerosolizing infectious material when disconnecting the ETT.

The surgical team is advised to re-enter the operating room only after the air has circulated through one cycle, which will vary depending on the specific number of air changes per hour set by that institution. The surgical team and support staff are advised to wear N95 masks throughout the procedure with appropriate eye protection. If the

situation requires an awake fiber-optic intubation in the positive pressure environment of the operating room, the surgical team should consider entering the operating room after the air has circulated through several cycles in order to reduce the viral load in the air. Standard PPE with an N95 respirator and eye protection is of course paramount for all practitioners entering the operating room.

Endotracheal extubation

If a negative pressure room is available, the patient should be transferred after completion of surgery for removal of the ETT. It is recommended to cover the patient’s face and upper torso with a clear plastic drape and extubate under that cover in order to avoid dispersing infectious material. Standard PPE has to be worn and all non-essential personnel should leave the room, whether extubating in a negative pressure environment or in the operating room. Patients should be extubated to nasal cannula, face tent or nonrebreather facemask. High flow nasal cannula and Bi-pap should be avoided due to the high potential for viral aerosolization from these oxygen-supplying modalities. If possible, nebulized medications should likewise be avoided because of the highly aerosolizing nature of this application method.

Personnel redeployment to ICU/ED

It became clear from an early point that the prospect of orthopedic surgeon redeployment to other areas of need within the hospital was a distinct possibility. This was due in part to anecdotal reports of redeployment in viral

epicenters as well as through correspondence with colleagues in Europe and Asia. Moreover, on March 23rd, the governor of New York mandated that all hospitals within the state increase their ICU capacity by 50% [31]. This increase in capacity had to be met with an increase in skilled workforce including nursing staff as well as physicians. By March 28th, exactly 1 month following the presentation of patient zero to our institution, the first orthopedic team was redeployed to the ED.

In order to spread the burden evenly across our department, a committee was convened by remote meeting and charged with planning redeployment strategically. It was decided to deploy teams of two providers to the ED, composed of one attending and one resident. Each volunteer was asked to submit his or her age and medical comorbidities, which were kept anonymous to the rest of the department. Risk factors for severe COVID-19 infections were identified and included age >60, HTN, DM, CV disease, obesity and immunosuppression [32]. Other considerations taken into account included child-care needs and ability to quarantine from members of the household. Lastly, those who had a known or suspected prior COVID-19 exposure and had recovered were placed at the top of the list under the assumption that they had obtained short-term immunity, although at this time it is unclear if or when immunity to SARS-Cov-2 is conferred. (Fig. 6) An antibody test, when available, will also help in the risk stratification as a significant number of healthcare workers have likely been exposed but are asymptomatic or have a mild illness with immunity. Housing outside of primary residences was made available for volunteer faculty and house staff to help

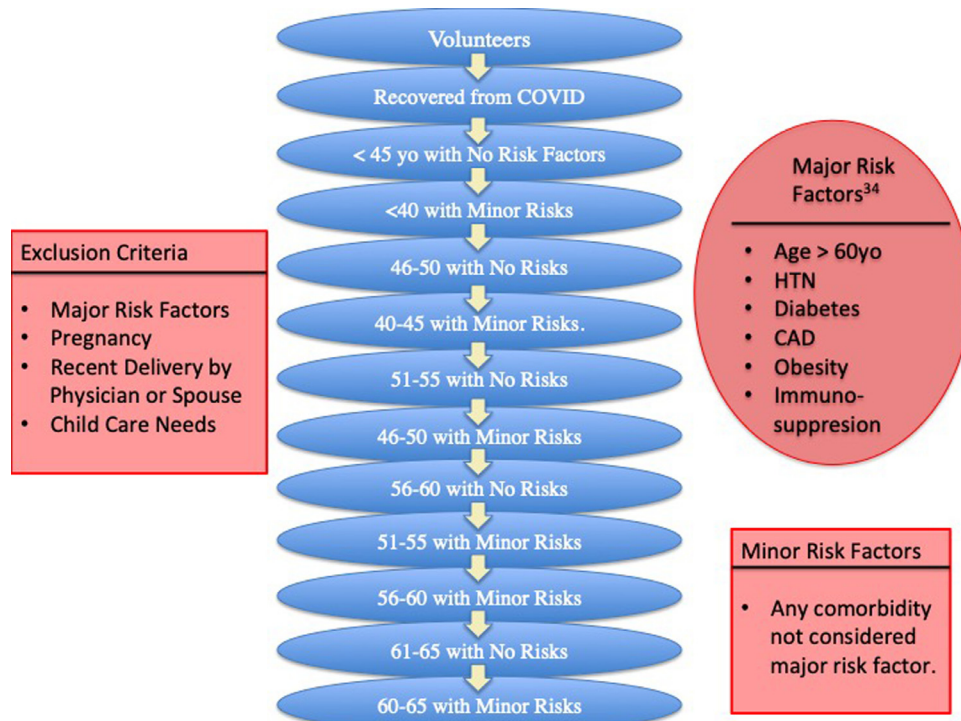


Fig. 6. Departmental redeployment scheme.

Resident and Faculty Redeployment Schedule

	Monday, April 6th	Tuesday, April 7th	Wednesday, April 8th	Thursday, April 9th	Friday, April 10th	Saturday, April 11th	Sunday, April 12th
MH ED Day Shift	Ortho Team	Ortho Team	Ortho Team	Ortho Team	Urology Team	Ortho Team	Urology Team
MH ED Night Shift	Urology Team	Urology Team	Ortho Team	Ortho Team	Urology Team	Ortho Team	Ortho Team
AH ICU Day Shift	Ortho Team	Urology Team	Ortho Team	ENT Team	Ortho Team	Ortho Team	Urology Team
AH ICU Night Shift	Urology Team	ENT Team	Urology Team	Ortho Team	Urology Team	ENT Team	Ortho Team

Fig. 7. Resident and faculty redeployment schedule.

eliminate concerns about spreading the virus to one's family. Faculty and house staff were then ranked for deployment depending on their risk stratification. It is vital to note that although redeployment was an important initiative to our department during this time of crisis, our primary concern was to maintain an adequate workforce to meet all orthopedic surgical demands at our institution.

When structuring the redeployment schedule, the risk to providers must be considered. It became clear that the number of exposures and duration of exposure should be limited to avoid overburdening clinicians in COVID positive areas. While 12 to 24 hour shifts may be preferred among some surgeons, we advocated for shorter, 6 to 8 hour shifts to spread the risk out over a larger number of clinicians. The logistics of this type of deployment limit the number of times in each shift that PPE needs to be donned and doffed and also reduces fatigue. Ultimately deployment shifts were split between multiple departments which further limited repeated exposure to our team. (Fig. 7). These teams would rotate to ensure that needs in the ED were met at all hours of the day, every day of the week. Initially, orthopedic surgeons and urologic surgeons shared ED coverage. Eventually, otolaryngology and ophthalmology joined the redeployment efforts. The staffing for these deployments should be based upon the skill set of the respective surgical services. Several of the spine surgeons (and especially the neurosurgeons) have ICU experience, and may be better off deployed to assist with the ventilated patients.

Due to aggressive measures taken by the hospital to divert low acuity patients, the total number of daily ED visits was not dramatically increased. However, the acuity of patients who necessitated prolonged ICU stays rose significantly. This led to increased critical care needs within the ED and the ICU. While the precise duties of redeployment vary depending on the assigned location, the overall role of the orthopedic surgeon was to provide support to the critical care team. Typical duties included obtaining arterial blood gasses for ventilated patients, placing orogastric and nasogastric tubes, assessing for adequate sedation, adjusting ventilator settings, monitoring vitals, ordering blood

pressure support and sedative medications, communicating between medical and consulting teams, and even aiding in patient transport between the units.

Particularly challenging was the preservation of PPE due to its critically short supply. Due to the virus' capacity to be aerosolized, N95 masks are recommended wherever aerosolizing procedures are commonly performed, primarily the ED and the ICU [30]. These procedures include intubation, extubation, bronchoscopy, cardiopulmonary resuscitation, noninvasive positive pressure ventilation, high flow nasal cannula, and nebulization. Ideally these procedures would be performed in a negative pressure room, but with the high volume of patients necessitating these procedures in the ED it was not deemed possible. Given the significant shortage of PPE, each provider was given one N95 mask at the beginning of his/her shift and expected to wear that mask throughout the shift or until it was visibly soiled. In order to prevent the N95 from becoming contaminated by droplets, it was covered with a typical surgical mask followed by a face shield. When the N95 mask had to be removed, such as for eating or drinking outside of the unit, the surgical mask would be replaced, allowing the respirator to be reused. When coming into contact with a COVID-19 positive patient, full contact precautions are to be observed. This includes use of an impermeable gown, gloves, face shield, N95 respirator, and surgical mask. (Fig. 8) When done with the patient visit, the gown and gloves are to be removed within the room. The provider should then leave the room, wash his or her hands, and then remove the face shield and surgical mask (if needed) leaving on the N95 followed by a repeated washing of hands. If cohorting COVID-19 positive patients in one room, consider leaving one's gown and surgical mask on and changing gloves between patients to conserve gowns and surgical masks.

Other useful guidance in the conservation and use of PPE:

- Place someone in charge of PPE distribution to prevent wasteful usage, hoarding, etc.

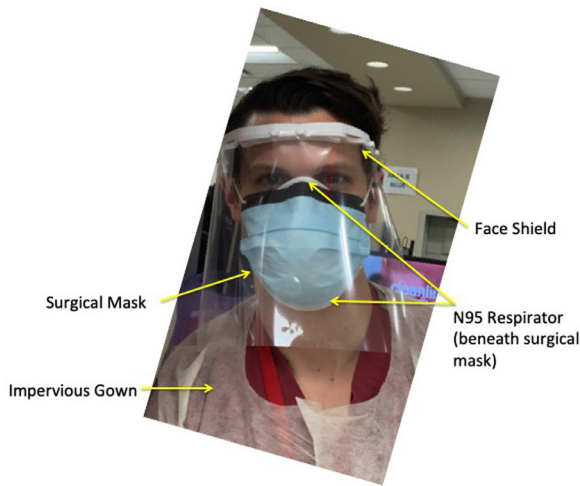


Fig. 8. Recommended personal protective equipment.

- Have clear protocols for every staff member as to who will require a surgical mask vs. an N95. In the early period of this pandemic little was known about how the virus is transmitted, resulting in wasteful consumption of PPE during patient contacts that didn't necessarily require it.
- Perform all procedures/labs/vital signs at once when a MD or RN enters the room; avoid multiple entries into the room.
- Minimize the team rounding on the patient to the attending or senior staff.

Lessons from the front line

In times of crisis, the similarities between physicians and soldiers become more evident. Both professions play an irreplaceable role in our society, seeking to serve for the greater good of the public. The following lessons have been adapted from soldiers' accounts in the battlefield and applied to our experiences during the COVID-19 pandemic [33].

1. *Embrace the buddy system:* The environment that healthcare providers face during the COVID-19 pandemic will in many ways be unfamiliar. This includes exposure to a novel pathogen that can endanger the health of physicians working on the front line. Having a "battle buddy" will serve as a physical and psychological crutch to keep providers out of harm's way. During our department's redeployment, battle buddies were charged with making sure their partner always had proper PPE, maintained safe procedural practices, and assisted in collective medical decision-making.
2. *Prepare for the unexpected:* Rarely in our nation's history have healthcare systems been stretched so thin in such a short amount of time. It is vital for departments to remain flexible and prepared for worst-case

scenarios. This includes lack of adequate PPE, team members unable to contribute due to illness, surges of new patients and absence of typical support staff. Taking the time to reflect on "what can go wrong" will enable institutions and departments to be better prepared.

3. *This is a team effort:* In every organization there are members who contribute to varying degrees. It is vital for the leaders in each department to recognize what each of their members' strengths and weaknesses are and to utilize them appropriately. By involving the entire department in decision making and redeployment, leaders can achieve camaraderie and a common sense of purpose. In our department, we recognized who was at higher risk for complications from the COVID-19 pandemic and deprioritized them for redeployment. Those providers instead increased their telemedicine visits as their primary contribution.
4. *Take breaks:* Our department recognized the dangers that fatigue can have on physicians who were deployed to COVID positive areas. Any lapse in stringent airborne and droplet precautions can have catastrophic repercussions. For this reason we implemented battle buddies, abbreviated and rotating shifts, and frequent breaks into our redeployment plan. Time away from the hospital also helped to alleviate the emotional or psychological stressors that physicians were exposed to.
5. *Communication is key:* Communication during the pandemic was vital for our department as a means of adapting, setting expectations and building camaraderie. After each shift, team members would email their experiences to the rest of the department. Through this mechanism, we were able to identify areas of improvement, hone our skills, describe the impact we were having on the areas of deployment and offer an outlet for emotional catharsis. These daily emails also allowed the leaders in our department to gauge the ongoing need for additional personnel to be redeployed. Likewise, communication from both hospital and departmental leadership was crucial for expressing the institution's needs to their healthcare workers. Daily live video updates from the hospital administrators with stories of selfless acts by employees served as constant morale boosters.

General wellness

Mental health

It has been shown that in times of national and international disasters, there can be an increased mental health burden on the population [34]. Liu et al. performed a survey study of healthcare workers in China during the COVID-19 pandemic [35]. Of the 4,679 respondents, 15.9% showed signs of psychological distress, 16.0% showed signs of

anxiety and a remarkable 34.6% showed signs of depression. In prior crises in New York City, such as the September 11th attacks, task forces were assembled for crisis management. Similarly, population-based strategies are currently being employed today. On a more individual level, our department started a “buddy” system, as described previously, at the beginning of the isolation period to ensure active engagement with peers. We also established connections with our departments of psychology and psychiatry for individuals to engage with mental health support as needed.

Education & communication

Engagement of faculty with meetings arranged through teleconference platforms was implemented early on to maintain education and peer interaction. Throughout the COVID-19 pandemic, in an effort to maintain resident learning and training, our department has continued all educational conferences by use of teleconference software. This includes departmental meetings such as the monthly morbidity and mortality conference. The Och Spine Hospital began with Monday and Wednesday morning educational video teleconferences, and maintained our usual Wednesday “huddle” (rotating between research meetings, morbidity and mortality conference, attending meetings and high-risk case conferences). Additionally, we have established a Wednesday morning national educational series among several institutions, and a Thursday evening meeting that is attended by over 200 surgeons worldwide. These allow us to maintain our national and international platform, and garner information from other institutions that are at different stages of the pandemic.

Social distancing

It is important to note that social distancing for health-care workers also includes distancing within the home. We have recommended that clinicians who are redeployed pack a second set of clothes to change into after doffing the uniform they used to treat the COVID-19 positive patients. They are recommended to then remove those clothes prior to entering their home, sometimes through an accessory entrance if possible, and place everything in a laundry bag to be immediately cleaned. They should then proceed immediately to the shower to decontaminate. It is recommended to use a different bathroom than other occupants in the household. If this is not possible, one should immediately clean the bathroom with disinfectant after use. Surgical masks are donned in the home and social distancing during meals and other interactions should apply. If allowable, one should sleep in a separate part of the house or apartment. Some clinicians prefer housing quarters away from the home although this has not been explicitly recommended by health authorities. Each institution should attempt to provide resources for available housing.

Exercise & nutrition

It is well documented that routine physical activity can have a profound impact on both overall health as well as mental wellbeing [36,37]. This is particularly true when socially isolating and remaining less active at home. Multiple phone and computer applications are available to help stimulate physical activity routines [38]. It is advisable to decrease regular exercise routines to 75% of the prior level of fitness to help stimulate the immune system and avoid paradoxical immunosuppression [39].

Regular nutrition and hydration are also necessary for optimal performance. Part of the rationale for recommending a shorter duration of shifts is to avoid dehydration or the repeated donning/doffing that would be required over the course of a 12-hour shift to maintain adequate hydration and nutrition. Physicians and surgeons often work continuously without a break in crisis scenarios and busy wards, leading to depletion of glycogen stores and dehydration. If one must work longer shifts, administrators should be sure to have a safe space for doffing and storing PPE for hydration and snack breaks. Additionally, supplying food can help to increase the likelihood that clinicians will eat during a long shift.

Conclusion

While we are hopefully nearing the apex of the curve in New York City, we know from other countries that this pandemic and its devastating effects will continue to roll across the United States in the coming months. We wanted to write this paper to provide some basic guidance, tips and pearls that we have learned as the “tip of the spear” in our country’s fight against the pandemic. We recognize that the above recommendations are the product of clinical expertise at a single institution with currently limited knowledge of the COVID-19 pathogen. As such, treatment protocols, resource utilization, and deployment strategies are likely to change as more is understood about this disease process and the unique challenges it places on every affected institution.

Looking ahead, we know life will forever be different. Similar to the World Wars and 9/11, these events transform our very fabric of existence. As General McChrystal stated in the foreword, in combating any enemy, an age-old axiom is to “improvise, adapt and overcome.” Indeed, the resiliency of the American spirit and those of our healthcare heroes will eventually overcome this invisible enemy.

It will now be up to our country’s leadership to prepare for the next catastrophe, pandemic, war or other challenge. We will be better prepared next time, and hope this experience serves to inform hospital systems across the United States and the rest of the world. As George Santayana stated in 1905, and Winston Churchill paraphrased in his speech in 1948, “Those who fail to learn from history are condemned to repeat it.”

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