



Essential Spine Surgery During the COVID-19 Pandemic: A Comprehensive Framework for Clinical Practice from a Specialty Orthopedic Hospital in New York City

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Introduction

During the March 18, 2020, White House Coronavirus Task Force Press Briefing, representatives from the Centers for Medicare and Medicaid Services (CMS) and the US Surgeon General's office announced a plan for all “elective” and “non-essential” surgeries and procedures to be delayed in order to enhance response to coronavirus disease 2019 (COVID-19) [21]. In the three-tiered CMS hierarchy, spine surgery was included in tier 2a, along with a recommendation to “consider postponing surgery” for “non-urgent spine” and “elective spine” procedures [8]. Deferring these services conserves beds, ventilators, personal protective equipment (PPE), and essential workforce and was therefore a priority for hospitals preparing for or experiencing a surge of patients with COVID-19. Postponing elective surgeries may

have minimized additional risk of exposure through social distancing, further protecting patients and healthcare workers. The CMS recommendations outlined several factors that surgeons may consider, including patient risk, availability of beds, staff and equipment, and the urgency of the procedure, but they lacked a clear framework to assist operative decision-making.

Translating the CMS recommendations into practical management and triaging of patients for surgical vs. non-surgical treatment have carried significant clinical and ethical challenges for spine surgeons. Which cases were “essential”? Which could wait? How could we temporize the condition of patients waiting for surgery during the surge of critically ill patients in the pandemic?

Conversely, the decision to operate required comprehensive anesthetic and peri-operative protocols for patients with known or suspected COVID-19. Such protocols had to achieve dual goals of protecting patients and practitioners, while conserving PPE and hospital resources. Although evidence had accumulated from countries afflicted earlier in the pandemic, these protocols needed to be evaluated and adapted to suit the local hospital environment and they often raised more questions than they answered [7, 13, 22, 31]. How could we protect the vital medical workforce and ensure the safety of COVID-19-negative patients admitted for urgent-emergent surgery? How could we screen for disease when testing capability lagged testing demand, and how could we safely reintegrate essential staff after a period of quarantine or illness?

Every surgery was accompanied by specific anesthetic risks which needed to be mitigated for optimal outcomes. However, unique additional challenges had to be addressed when caring for spine surgery patients during the surge phase of the pandemic. How could pre-operative evaluation and optimization be achieved while respecting social distancing orders? Could we safely use steroids and non-

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steroidal anti-inflammatories (NSAIDs) in COVID-19 patients? How could we safely intubate and extubate, particularly when spine surgery patients frequently require complex airway management?

Finally, several issues surrounded the practical and ethical distribution of resources during the surge crisis. How could we consistently allocate peri-operative resources when planning for post-operative care and/or complications? This included not only intensive care unit (ICU) services and ventilators but also blood management in a time of progressive shortages, and allied physical therapy, nursing, and pain management services.

As spine surgeons and anesthesiologists at a specialty orthopedic surgery hospital in New York City, we were confronted with these questions early in the pandemic. Here, we share our experiences in developing the Hospital for Special Surgery (HSS) Spine Care Institute's response to the challenge of providing care at the leading edge of the COVID-19 pandemic. Key institutional, surgical, and anesthetic aspects of the response are presented and which when implemented together addressed the important questions raised here.

Institutional Considerations

In conjunction with New York City and statewide planning, our hospital was a designated COVID-19 treatment facility. At the time of writing, we continued to function as a specialty care musculoskeletal treatment center, but between March 17 and June 8, 2020, all elective surgical procedures were postponed. Our new secondary function was to support our partner institutions in New York City by accepting COVID-19 patients, citywide orthopedic trauma patients, and general medical and surgical patients, where such admissions would free capacity at other hospitals and assist broader efforts to redistribute care for COVID-19 patients. This represented a unique care model, but one which could be replicated in other cities as a solution to balancing care for COVID-19 patients with ongoing surgical needs of patients in the community. Where hospital systems lack a dedicated freestanding building, separation of patients by COVID-19 status may be achieved by designating restricted areas within a hospital.

Early in the pandemic, the institution created a dedicated team to evaluate the available evidence and create a set of interventions to minimize the viral spread and to protect staff and patients. A policy was developed according to best-practice recommendations by the Centers for Disease Control and Prevention (CDC) and the New York State Department of Health (NYSDOH). The details and advice changed frequently, so those policies had to be continually updated. Thus, the goal was to identify and create the necessary policies which were appropriate for the institution. Three key areas for policy were identified: (1) patient and visitor screening, use of patient-PPE, and patient isolation practices [4]; (2) staff policy for self-surveillance of symptoms, what to do in the event of

exposure, and self-quarantine practice [5]; and (3) staff testing and return to work after illness [3, 18].

A no-visitor policy for adult inpatients and no-accompanied-visitors policy for office-based appointments were implemented [4]. On arrival to the hospital, all patients underwent risk factor screening and temperature check. Because at the time New York City bore the highest burden of COVID-19 in the country, surgical face masks were provided to all patients on arrival. A fever ($\geq 100^\circ\text{F}$) was reported to the infection control team on duty and the febrile patient was isolated. Early in the pandemic, the risk factor screening focused on recent travel to affected countries and symptoms of concern. As community spread overtook travel-related acquisition, the risk factor screening was amended to emphasize close contacts with known or suspected COVID-19.

The incubation period of COVID-19 is typically 3 to 7 days and no more than 14 days, although the virus can be shed in the asymptomatic patient for longer periods [12, 13]. Consistent with recommendations from the Centers for Disease Control and Prevention (CDC), the workforce with known exposure to COVID-19, irrespective of symptoms, must self-isolate for a minimum of 14 days [5]. Likewise, staff with unknown exposure but with active symptoms (fever $\geq 100^\circ\text{F}$, cough, shortness of breath) were advised to stay home and inform both Occupational Health Services and their primary healthcare provider. Those with no known exposure and no symptoms of concern were advised to monitor their health and check for fever ($\geq 100^\circ\text{F}$) twice daily.

Our return to work policy after a period of quarantine was based on the CDC and NYSDOH guidelines for healthcare personnel with confirmed or suspected COVID-19 [3, 18]. The guideline included a test-based and a non-test-based strategy. Since like many institutions, ours cannot perform widespread testing for staff; we adopted a non-test-based strategy. This decision highlights how national recommendations need to be adapted to local conditions and modified as conditions change. Consistent with the CDC non-testing strategy, our personnel were not permitted to return to work for at least 72 h after the resolution of fever without the use of fever-reducing medications, improvement in respiratory symptoms, and at least 7-day duration since the onset of symptoms. Employees were further required to confirm their status with Occupational Health prior to returning to their duties.

In the setting of adequate testing capacity, the goal was to shift to a test-based strategy to assess patient and staff status. Indeed, rapid 5-min COVID-19 tests (Abbott Labs, Abbott Park, IL, USA) received FDA clearance on March 27, 2020. However, until their universal accessibility, and demonstrated high sensitivity and specificity, the precise COVID-19 status of patients will likely not be known. Therefore, surgical and anesthesia teams must be prepared for the possibility that operative patients may be COVID-19 positive and manifest symptoms in the post-operative period which may require subsequent specialty care.

Surgical Considerations

When elective surgeries were suspended, each surgical service line was charged with developing a list of essential surgeries. Essential spine surgery is defined as follows:

- progressive or unstable myelopathy
- spinal cord at risk structural findings: myelomalacia in the setting of cord compression or cord compression with structural instability including trauma, fracture, junctional failure, and tumor
- acute or progressive cervical or lumbar radiculopathy
- progressive weakness, foot drop, and cauda equina syndrome
- disabling or escalating pain requiring escalating opioid analgesics in the setting of structural instability or critical stenosis/nerve compression
- infection

Our algorithm for treatment first called for screening of any of the above conditions (Fig. 1). If surgery was indicated, we evaluated risk factors related to the predicted post-operative course and expected requirements for hospital resource consumption. These included ICU admission, mechanical ventilation, anticipated blood loss and probability of transfusion, need for consults from allied medical and pain management services, and length of stay. The appropriateness of a home discharge destination was also considered. If resources were available and/or the patient was deemed low medical risk/at low risk of requiring resources, a secondary assessment of COVID-19 status was performed. This assessment considered the patient's known or suspected status and recognized risk factors for poor outcomes associated with COVID-19 (male gender, age over 65 years, hypertension, diabetes mellitus, cardiovascular disease, or pulmonary conditions) [2, 27–29]. If the patient was low risk for testing positive for COVID-19 and for having major complications of COVID-19, surgery was recommended. Conversely, if the patient had complex medical needs with anticipated lengthy post-operative stay, significant resource consumption, and the necessary resources were not guaranteed, delaying surgery was recommended. Patients with known positive status and/or symptoms of COVID-19 required further special consideration. Here, the decision to operate was made according to the risk of delaying surgery versus the severity of COVID-19 symptoms. Consensus from the peri-operative team was required. In all cases, a careful discussion was held with the patient to present specific risks of having surgery during the COVID-19 pandemic, including nosocomial infection and unpredictable availability of resources. For particularly challenging decisions in COVID-19 patients, we included a consultation from our bioethics and palliative care services, in which goals of care were defined with the patient and family members.

The algorithm is applied not only to patients who were already in the surgical queue but also to new patients seeking urgent consultation. In an effort to maximally screen and distance patients and staff, we limited the flow of patients into any clinical space (in both the hospital and outpatient clinics). Only patients for whom a face-to-face review was

deemed essential (based on an accurate assessment of the above criteria) were scheduled for the outpatient clinic.

A telemedicine program was implemented and expanded as the first point of new patient contact [20]. During this first virtual appointment, new patients were triaged based on the aforementioned criteria. If the presenting condition was non-essential, an initial conservative therapy program was initiated with a plan for in-person follow-up at a future date. If the patient presented with an essential condition, then the patient was scheduled to be seen immediately in the centralized and controlled dedicated spine clinic space. That space was designed to screen all new patients for relevant COVID-19 risk factors and fever through thermal imaging. Once indicated for surgery, the patient moved through a protected virus-negative space for medical screening, imaging, and eventually surgery.

Patients were monitored during the post-operative inpatient period carefully with a low threshold for isolation and COVID-19 testing based on symptoms. We eliminated the option of acute rehabilitation hospital placement and discharged all patients to home with the appropriate visiting services.

Routine post-operative surgeon visits were carried out via telemedicine unless an urgent in-person evaluation was mandated. In this case, the same outpatient clinic procedure was followed.

Anesthetic Considerations

General

Anesthesiologists are among the healthcare workers at highest risk of contracting COVID-19 during patient care [7, 16, 30]. The risk may be even higher during essential spine surgery, because of the need for close, sustained contact during complex airway management and for post-operative care in the ICU. Development and implementation of safe procedural protocols to prevent infection were needed in parallel with preparation for the unique challenges that essential spine surgery presents throughout the peri-operative period.

Pre-operative Evaluation

Under these conditions, the anesthetic pre-evaluation should be performed via telemedicine consult as part of surgical pre-operative planning. Although a comprehensive physical examination is precluded, an airway examination and range of motion at the neck can both be performed. On the day of surgery, a secondary evaluation can be performed by the anesthesiologist, focusing on cardiopulmonary assessment and re-assessing risk factors for COVID-19. If COVID-19 is newly diagnosed or strongly suspected, the patient should be isolated, ideally in a negative-pressure room. The attending surgeon should be consulted to confirm whether the procedure should be postponed for testing and treatment as needed. Once cleared for surgery, COVID-19 patients are transferred from the isolated holding area room to a dedicated operating room.

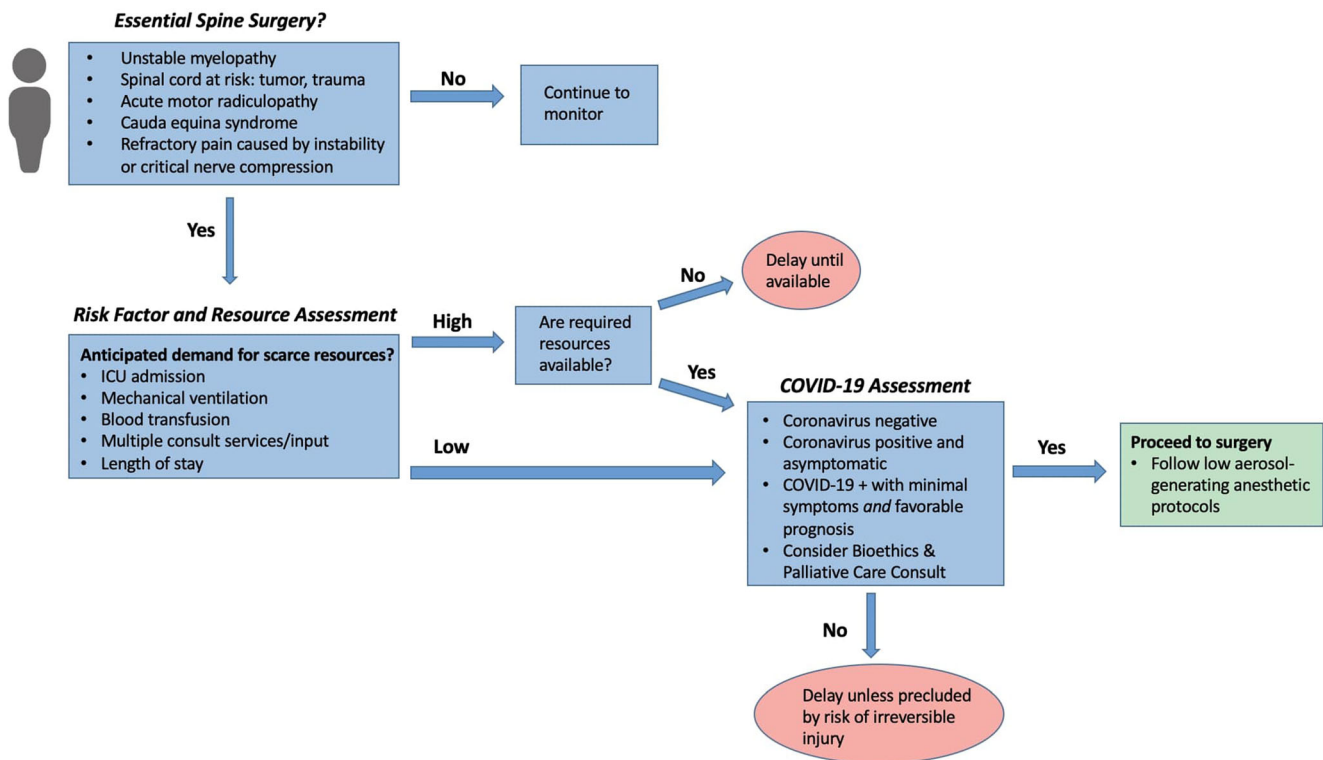


Fig. 1. Surgical decision-making algorithm.

Intra-operative Care

The PPE for the anesthesiologist includes at minimum an N95 mask for aerosolizing procedures (including intubation), eye protection (goggles or face shield), paper gown, and double disposable gloves [1]. A dedicated operating room with negative pressure airflow is recommended for the operative management of patients with confirmed or suspected COVID-19 [7, 16]. Like many hospitals, ours does not have universal negative-pressure operating rooms. In lieu of this, a 20-min “lockout” period was instituted after intubation and extubation to allow air turnover to clear potential viral particles. During these times, all non-essential staff leave the operative room.

There was a lack of consensus on the requirement to disinfect the anesthesia machine between suspected COVID-19 patients. Guidance from the Anesthesia Patient Safety Foundation suggested that at a minimum, a high-efficiency viral filter be placed between the breathing circuit and the patients’ airway to prevent contamination [1]. Our practice is to place a second filter at the end of the expiratory limb at the connection to the anesthesia machine and to change the water trap between every patient. The filter is changed after every 4 h of anesthesia time and between patients. Although each manufacturer has processes for decontamination, this can be labor and time intensive and can remove the anesthesia machine from service for a protracted period [1]. Thus, efforts to prevent contamination should be emphasized wherever possible.

During a pandemic, general anesthesia with endotracheal intubation is recommended to minimize any coughing and bucking that can generate airborne droplets [9, 16, 19]. A rapid sequence induction with video laryngoscopy should be performed. The chief advantage of this technique is avoidance of positive pressure face mask ventilation, which can generate substantial airborne droplets. Additionally, the distance between the anesthesiologist and the patient’s airway can be maximized by avoiding direct laryngoscopy.

Awake fiberoptic intubation (FOI) is discouraged in patients who test positive for SARS-CoV-2, the virus that causes COVID-19, since this technique carries the highest risk of coughing during intubation. This presents a unique challenge for spine surgery patients, since awake FOI is not infrequently needed for cervical spine procedures. To balance the risk between anticipated difficult intubation and spread of the virus, we recommend a rapid sequence asleep FOI be performed by the most experienced practitioner available. If the assistance of the ear, nose, throat surgeons is planned for the surgery itself, these personnel should be present during anesthetic induction and intubation. If performed, a single-use, disposable fiberscope is preferred. Where an awake FOI cannot be avoided, the airway should be topicalized, appreciating that transtracheal blocks and delivering local anesthetics via atomizer substantially raise the risk of cough and aerosolization of respiratory droplets. Irrespective of the strategy selected to secure the airway, a closed suction system should be used together with the minimal number of suctions possible to manage airway

secretions. Confirmation of endotracheal tube position by auscultation of the chest may be challenging depending on PPE. Rather, direct visualization of the endotracheal tube passing the vocal cords, bilateral chest rise, and satisfactory capnography should be emphasized.

Although the unanticipated difficult airway is omnipresent irrespective of coronavirus status, preparation for the cannot-intubate-cannot-ventilate scenario should be more extensive, since help is limited and time for additional providers to don PPE may be significant.

Extubation of the airway is the phase of care with the highest risk of aerosolization [9]. Where possible, patients should be extubated in a negative-pressure room, either an operating room or a negative-pressure room on the ICU. The minimum number of personnel to ensure safety should be present. Techniques to maximize safety include shrouding the patient for extubation and deep-extubating techniques. Although the latter technique has advantages for preventing coughing and bucking on emergence from anesthesia, this should be discussed between the anesthesiology and surgical teams and agreed on a case-by-case basis. There can be a significant delay to full neurological examination after deep extubation, and the technique may not be suitable for anterior cervical procedures. Finally, anesthesia teams unfamiliar or uncomfortable with performing deep extubation on a routine basis are advised to perform a shrouded extubation.

Use of Steroids and Non-steroidal Anti-inflammatory Drugs in Spine Surgery Patients

A recent editorial in the *Lancet Respiratory Medicine* suggested medications that elevate serum angiotensin-converting enzyme (ACE) could raise the risk for major complications of COVID-19 [11]. Observational studies have long associated NSAIDs with higher rates of cardiovascular events, including myocardial infarction, heart failure, and stroke [17, 26]. These risks are further increased when NSAIDs are used during acute respiratory tract infections [25]. NSAIDs can also cause nephrotoxicity, which is more likely in patients with critical illness, and may be exacerbated by fever and dehydration [30]. Although biologically plausible, at the time of writing, there is no evidence to demonstrate the association between NSAIDs and worse COVID-19 outcomes [15]. Indeed, patients with COVID-19 might benefit from symptomatic relief that NSAIDs can provide. Likewise, patients with spinal pathology which does not meet the criteria for essential surgery may have significant relief of musculoskeletal pain with NSAIDs. Pending further research and evidence to the contrary, a reasonable approach would be to continue NSAID therapy with close monitoring of renal function and low threshold to discontinue medication if COVID-19 symptoms present or worsen during the pre-operative phase.

Steroid therapy should be carefully considered in all patients presenting for essential spine surgery. Patients taking supraphysiological doses of glucocorticoids prior to surgery may have increased susceptibility to COVID-19, due to the immunosuppressive effects of the steroids and/or underlying conditions for which the steroids are

prescribed. Stress dose steroids should be considered in any SARS-CoV-2-positive patient who is also taking steroid therapy [14]. The relative risks of peri-operative steroids for patients undergoing essential spine surgery on subsequent susceptibility of COVID-19 and related outcomes are unknown. Thus, the decision to give or withhold steroids should be made on a case-by-case basis according to individual risk/benefit.

Ethical Considerations and Allocation of Scarce Resources

Setting limits on access to treatment, allocating PPE to high-risk procedures and diverting healthcare workers according to need were all indications that rationing was a component of the national response during the surge crisis of the pandemic [10]. The concept of rationing applied not only to global resource allocation to patients with COVID-19 but also to patients with “elective” conditions which could have become essential without prompt surgical intervention. Thus, the final decision to perform spine surgery during the surge of the pandemic was made only after considering what additional care may have been required, and with knowledge of the institution’s available resources, expected duration and consumption of hospital and ICU services, and the potential for discharge to a safe destination.

The availability of autologous blood was disproportionately affected by the COVID-19 pandemic and merits special consideration for essential spine surgery. Due to an unprecedented number of blood drive cancellations and the consequences of social distancing, the American Red Cross estimated that reserves were at 60% of usual supply during the surge crisis [23]. Given that blood shortages have persisted despite passing the peak of the pandemic in New York City, the predicted need for autologous transfusion should be incorporated into the decision to proceed with essential spine surgery for the immediate future. It should also be recognized that procedures with anterior or lateral approaches carry the risk of major vascular injury, which could require massive blood transfusion. Where the risk of injury is deemed high, the alternative would be to perform the procedure via posterior approach.

Although donated blood is not screened for SARS-CoV-2, the risk of transmission via blood transfusion has been estimated to be low [6]. Donors should be asked a series of screening questions and subject to a temperature check before donation. In a recent advisory to blood collection establishments, the FDA recommended patients could report a post-donation diagnosis of COVID-19. Blood establishments could also consider tracing and removing blood products collected in the 28 days prior to diagnosis or symptom onset [24].

In conclusion, spine teams need to rapidly redefine risk versus benefit of essential surgeries during the COVID-19 pandemic. Where possible, it is reasonable to defer surgery to conserve resources, consistent with nationally declared public health goals. At the same time, it should be acknowledged that spine surgery is often not truly elective in nature, and symptoms can progress so that an elective case without prompt intervention becomes urgent or emergent. We

propose that decision-making about operative intervention should be made on a case by case basis, accounting for patient status and the risks and benefits of delaying surgery, the availability of resources at the time of the proposed surgery, and the safety of practitioners and patient if surgery is performed. In making these difficult decisions, patient preferences and meticulous post-discharge planning are essential to optimal outcomes.

Having defined an algorithm to triage and manage spine surgery patients during the pandemic, we propose that future studies should now assess ongoing workflow and patient-related outcomes. Chief among these include the volume of patients whose surgeries were delayed, how many patients are now prepared to present for surgical interventions, the type of and indication for surgery, and how the delay affected disease course and progression. Of particular relevance for spine surgery, the effects of delaying elective surgery on pain and opioid consumption should be quantified and patients who required escalating doses of opioids should be identified. Finally, for patients with COVID-19 who undergo spine surgery, general and spine-specific outcomes should be described.

Compliance with Ethical Standards

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