

COVID-19 and Spine Surgery: A Review and Evolving Recommendations

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Abstract

Coronavirus-19 (COVID-19) has disrupted the normal delivery of healthcare for spine surgeons across the world. In this review, we will provide an overview of COVID-19's clinical features, and discuss the optimization and treatment of spine pathology during the ongoing global pandemic.

Keywords

spine surgery, COVID-19, SARS-COV-2, coronavirus, pandemic, public health

Introduction

In December 2019, a novel coronavirus, severe acute respiratory syndrome coronavirus-2 (SARS-COV-2) or coronavirus-19 (COVID-19), was discovered in Wuhan, People's Republic of China.¹ It has since been declared a global pandemic by the World Health Organization (WHO),² and as of April 5, 2020 the virus has infected 183 countries/regions, resulting in 1 274 923 confirmed infections, and 69 479 deaths.³ The pandemic has disrupted societal norms, increased healthcare utilization, and precipitated global economic instability. In the modern era, the scale and severity of the COVID-19 pandemic is unprecedented. In this review, we will provide an overview of COVID-19's clinical features and discuss the optimization and treatment of spine pathology with the goals of minimizing patient and provider risk, and conserving health care resources.

COVID-19

Viral Characteristics

COVID-19 is the disease caused by the SARS-COV-2 virus, which belongs to the same coronavirus family as prior endemics such as severe acute respiratory syndrome (SARS)-COV and the Middle East respiratory syndrome (MERS)-COV.⁴ The novel SARS-COV-2 virus is primarily transmitted through direct routes, such as respiratory droplets from coughing or sneezing, or direct person-to-person contact.^{5,6} Indirect transmission can also occur through aerosolized particles that remain airborne, or through contact with contaminated surfaces on which the virus can remain detectable for up

to 3 days.⁷ The median incubation period between exposure and clinical presentation of symptoms is 3 to 5 days, but may be as long as 14 days.⁸⁻¹⁰

Clinical Presentation

In patients who contract the SARS-COV-2 virus and develop COVID-19, the full spectrum of disease is highly variable and ranges from mild, self-limiting respiratory illness to progressive pneumonia causing possible respiratory failure and death.⁹ In most patients, the disease is mild and limited to nonspecific symptoms such as fever (98%), cough (76%), and myalgia or fatigue (44%).¹¹ Less common symptoms include sputum production (28%), headache (8%), and diarrhea (3%).¹¹ Based on data out of China, approximately 80% of patients develop mild to moderate disease, 14% experience severe disease (dyspnea), and 6% are deemed critical and may develop a hyperinflammatory response, septic shock, or acute respiratory distress syndrome (ARDS) requiring possible mechanical intervention or extracorporeal membrane oxygenation.^{11,12}

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Epidemiology and Risk Factors

Epidemiological data on COVID-19 is continually being analyzed and published. Based on data out of China, the median age of patients who developed symptoms was 47 years, and 87% of cases occurred in patients aged between 30 and 79 years.^{9,12} Fifty-eight percent of cases occur in male patients and less than half of patients have underlying chronic medical conditions.¹¹ The overall mortality rate is 2.3%, but in patients 80 years and older, the rate was approximately 15%.¹² Aside from increased age, the mortality rate is higher in patients with comorbidities including cardiovascular disease, diabetes, pulmonary disorders, and cancer.¹³⁻¹⁵

Diagnosis

The diagnosis of COVID-19 is based on obtaining an epidemiological history focusing on possible exposure risk, clinical symptoms, lab results, and diagnostic imaging, if indicated. Currently, reverse transcription–polymerase chain reaction (RT-PCR) and real-time reverse transcription–polymerase chain reaction (rRT-PCR) are used to detect the SARS-COV-2 virus in respiratory samples. However, the results of these studies can be affected by many factors including quality of the sample, sampling technique, and overall viral load. If the threshold of viral shedding is below that identifiable by RT-PCR, then a false negative result may occur, which is more likely early in the disease course before symptom onset and later, after symptoms have resolved.¹⁶ Serology antibody testing is also being developed for diagnosis of active infection and to assess for possible prior exposure and immunity, but is currently not available for widespread use.

Treatment

There are 282 studies registered at clinicaltrials.gov to investigate the efficacy and safety of several different medications and vaccines for COVID-19, but no treatments are approved to date. Current management focuses on early detection, isolation, and treatment of viral symptoms. Off-label and compassionate use therapies have been reported using medications such as remdesivir, ribavirin, favipiravir, lopinavir-ritonavir, chloroquine, hydroxychloroquine, azithromycin, steroids, and convalescent plasma.

Hydroxychloroquine has received significant media attention after a study showed a reduction in viral load, potentiated with the addition of azithromycin, in hospitalized patients with COVID-19.¹⁷ However, a later, smaller study failed to demonstrate clinical benefit when using the same drug combination.¹⁸ Chloroquine is also being investigated by several trials and early results have demonstrated some clinical efficacy.¹⁹ The major limitation of most of these studies is the small sample size, lack of randomization resulting in selection bias, and absence of a control arm; these limitations prevent the recommendation of widespread use of these medications. Perhaps the most well-designed study to date was a randomized, controlled,

open-label trial investigating the efficacy lopinavir-ritonavir versus standard care, but no clinical benefit of the antiviral combination was noted.²⁰

Aside from treatment of the active disease, pharmaceutical companies are working to develop an effective vaccine to prevent future cases of COVID-19. Several phase-I trials are registered on [ClinicalTrials.gov](https://clinicaltrials.gov). In March 2020, Kaiser Permanente Washington Health Research Institute gave the first injection of an investigational vaccine for SARS-COV-2 in a federally funded trial. However, it may take several months to years before safety and efficacy are fully assessed and manufacturing processes are streamlined.

Public Health and the Role of the Spine Surgeon

In the setting of the current pandemic due to the highly transmittable SARS-COV-2 virus, spine surgeons have a crucial role to play whereby they still treat patients with urgent and emergent spinal pathology while maximizing patient and provider safety and minimizing healthcare resource utilization. This is particularly important because many spine patients may be at increased risk (older age with medical comorbidities) of progressing to a severe stage of COVID-19.

With regard to health care utilization, as the number of COVID-19 cases continues to rise throughout the world, there is growing concern that health care systems may reach surge capacity and be unable to care for patients with moderate to severe symptomatology, particularly patients requiring mechanical ventilation. By delaying elective procedures, spine surgeons can help preserve several hospital resources including health care providers who would otherwise be in the operating room (OR), inpatient beds, intensive care unit (ICU) ventilators, blood bank reserves, and personal protective equipment (PPE) that would normally be consumed during surgery. Furthermore, delaying elective surgery avoids potential prolonged postoperative inpatient stays, decreases the risk of nosocomial COVID-19 transmission, and avoids having to treat postoperative complications in a setting where health care resources are already limited. Identification of what spine cases can be delayed is discussed later in this review.

In order to avoid hitting the surge capacity threshold, public health officials have implemented “stay at home” orders in many regions of the world to slow the virus’s spread and “flatten the curve.” Spine surgeons can play a part in “flattening the curve” by rescheduling outpatient clinic visits allowing patients to stay home, thereby limiting patients’ risk of transmitting or being transfected with the virus. The role of telemedicine as an alternative to outpatient visits will be discussed later in this review.

Triaging Spine Surgery During the Pandemic

The identification and triaging of patients with spinal pathology that need emergent or urgent surgery versus those who can be delayed several months is a gray zone without clear

Table 1. Guide to Outline a Triage System of Spine-Specific Surgical Care.^a

Category	Clinical Considerations	Recommendation
Emergent	<ul style="list-style-type: none"> Progressive or severe neurologic deficit due to neurologic compression from any cause Spinal instability at risk of causing neurologic injury from any cause Epidural abscess requiring surgical decompression Postoperative wound infection 	Do not delay
Urgent	<ul style="list-style-type: none"> 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 emergency room presentation, severe functional limitations and/or excessive opioid use despite nonprocedural attempts at management (eg, painful disc herniation, painful fracture, progressive fracture related deformity). 	Proceed if local health care guidelines permit such cases to occur and there are adequate health care resources available to safely perform the procedure
Elective	<ul style="list-style-type: none"> Spinal conditions where pain and dysfunction can be reasonably managed without procedural intervention during the pandemic (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

^a The table is adapted from The North American Spine Society (NASS).²⁵

consensus. In an attempt to minimize consumption of health care resources, the American College of Surgeons (ACS), United States Centers for Disease Control and Prevention (CDC), the Orthopaedic Trauma Association (OTA), and the Royal College of Surgeons (RCS) of England have all published guidelines to offer a framework of triage.²¹⁻²⁴ Spine surgery triage has its own unique set of challenges and the acuity of cases may be higher than many other surgical specialties. Recently, the North American Spine Society (NASS) developed a guidance document and the authors’ current recommendations for triaging surgical spine cases are largely based on this document (Table 1).²⁵

In general, cases with progressive or severe neurologic deficit due to neurologic compression from any cause, spinal instability at risk of causing neurologic injury, epidural abscesses with neurologic deficit, and postoperative wound infections should not be delayed. Myelopathy with recent progression, spinal infections refractory to medical management, persistent (not severe) neurologic deficits, and spinal conditions resulting in intractable pain or functional limitations limiting activities of daily living and self-care should proceed if local health care guidelines permit such cases to occur and there are adequate health care resources available to safely perform the procedure. Spinal conditions where pain and dysfunction can be reasonably managed nonoperatively should be postponed. These triaging decisions remain the responsibility of the spine surgeon who must act responsibly within local

health care delivery systems while complying with federal, state, and local health policy guidelines.

Operating Room Precautions

Strong consideration should be given to testing all patients for COVID-19 who undergo emergent or urgent spine surgery, particularly given that patients may remain asymptotically infected and contagious.²⁶ In the event that testing is unavailable or test results are not available and delaying the surgery is not clinically permissible, surgical procedures should be performed with the assumption that the patient has COVID-19.

Operating Room Setup

For patients with COVID-19, dedicated operating rooms for COVID-positive patients should be utilized. Consideration should be given to converting these dedicated ORs to negative pressure rooms as has been previously described.²⁷ If ORs cannot be converted to negative pressure, modifications should be made to minimize outflow from the contaminated OR. All instruments such as computers, telephones, ventilators, and carts should be covered. Preoperatively, the room should be stocked with sufficient amounts of medications, fluids, and other equipment anticipated to be needed during the surgery; this allows for minimization of operating room traffic. When feasible, disposable equipment should be used.

During surgery, consideration should be given to minimally invasive techniques when feasible and safe, which may decrease the risk of viral transmission thoroughly bodily fluids. Surgery should be performed by the most experienced provider available; procedural training of residents and fellows should take the backstage. Prone position is preferred to minimize viral transmission for respiratory or aerosolized droplets. Caution should be given to avoiding bodily fluid splatter and consider using a smoke evacuator to minimize electrocautery smoke in the operating room.

Operating Room Personnel and Personal Protective Equipment

The number of members of the surgical team should be minimized as safely as possible. OR personnel should limit traffic and entry/exit from the operating room. All staff should be educated on the proper donning and doffing of PPE. Standard OR PPE should be used in addition to N95 respirators. Consideration should be given to using a surgical hood/helmet. Last, all OR staff should be encouraged to look out for each other and report errors of PPE use or possible PPE contamination.

Intubation and Extubation

SARS-COV-2 can be transmitted through direct contact via respiratory droplets or indirect contact via aerosolized viral particles or exposure to contaminated surfaces.⁵⁻⁷ It is for these reasons that intubation and extubation are likely the highest risk components of spine surgery. When possible, intubation should be performed in a negative pressure room. It is advisable that all nonessential staff exit the room during intubation. Consideration for video laryngoscopy as opposed to direct laryngoscopy for intubation to increase provider working distance has been described and anesthetic guidelines for managing the airway for COVID-19 positive patients should be considered.²⁸ After intubation, consideration should be given to waiting 15 to 30 minutes before allowing OR staff reentry to the OR; this allows for air exchange to occur after intubation and minimizes viral transmission via aerosolization. A similar wait time should be considered after extubation. Standard relief protocols for anesthesia providers may need to be modified with the goal of minimizing exposed personnel and limiting OR traffic.

Patient Transfers and Postoperative Recovery

When the procedure is complete, sufficient sedative and muscle relaxant should be administered to prevent coughing or patient movement during transfer. COVID-19 patients should be transported using dedicated routes and elevators, if possible. These patients should also be sent back to the ward or ICU and monitored by dedicated staff as opposed to recovering in the general postanesthesia care unit, to minimize risk of nosocomial transmission.

Room Cleaning

Extrapolating from data and recommendations after operations on MERS- and SARS-exposed patients, thorough standard OR decontamination with dilute chlorine bleach may be sufficient.^{27,29} OR surface disinfection twice, as opposed to once, can also be considered.²⁷ A 1-hour interval between cases will allow for further dilution of aerosolized contaminants.²⁹ Reusable operative equipment can be processed using preexisting protocols and this has been shown to be effective against SARS-COV-1.³⁰

Call/Inpatient Management

In the setting of a pandemic, usual spinal pathology, particularly from trauma, will continue to occur, albeit at likely decreased rates due to quarantine and “stay at home” government orders. Spine surgeons will still have to take call, evaluate emergency room patients in a timely manner, and manage inpatients. Consideration should be given to segregating providers into teams that either manage inpatients, operate, provide on-call evaluations, or manage the outpatient setting when feasible.³¹ These teams should not come into contact with each other and can alternate on a weekly basis.³¹ Furthermore, to minimize health care provider exposure and keep a potential reserve of provider staff available, these teams should consist of as few providers as possible.

Outpatient Management

Telemedicine should be utilized if the expertise and infrastructure is available to both the provider and patient. During the pandemic, telemedicine allows for minimization of exposure risk to providers while allowing patients to also stay at home and comply with public health recommendations. Several recent documents have been published to assist providers regarding insurer policies,³² coding,³³ and COVID-19 telemedicine guidelines.³⁴ The Centers for Medicare and Medicaid Services (CMS) have made some recent changes to facilitate telemedicine use, including allowing evaluation of beneficiaries who only have audio phones, and reimbursement at the same rate as in-person visits for many diagnoses, not those just related to COVID-19. Last, the Health and Human Services (HHS) Office for Civil Rights (OCR) stated they will not impose Health Portability and Accountability Act (HIPAA)-related penalties for using video applications provided by companies such as Apple, Google, or Skype.

For patients that require an in-person exam, screening protocols should be implemented to identify patients with COVID-19 or probability of having COVID-19-related symptoms that warrant further testing. Patients should be screened for recent fevers, respiratory tract symptoms, and a positive travel or contact history. Patients with a positive response to any of the aforementioned items should be referred for possible COVID-19 testing. For patients who pass initial screening, exams should be performed using a surgical mask and gloves,

following strict hand hygiene practices, and maintaining as much distance from the patient as clinically feasible.

Conclusions

The ongoing COVID-19 global pandemic is unprecedented in modern history. Spine surgeons have a crucial role to play as provider, conservator of health care resources, and public health advocate. The appropriate triaging of patients who need emergent or urgent surgery versus those patients with surgical pathology that can be safely delayed will help preserve health care resources that can be reallocated to treat patients with COVID-19. The optimization of health care provider safety in the inpatient setting and operating room will decrease the risk for health care worker infections. Last, maximizing the use of telemedicine in the outpatient setting will help contribute to public health efforts focused on minimizing viral transmission by community spread.

Declaration of Conflicting Interests



Nickul S. Jain, MD¹, Ram K. Alluri, MD², Steven S. Schopler, MD¹, Raymond Hah, MD², and Jeffrey C. Wang MD

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References

1. Zhu N, Zhang D, Wang W, et al; China Novel Coronavirus Investigating and Research Team. A novel coronavirus from patients with pneumonia in China, 2019. *N Engl J Med*. 2020;382:727-733.
2. World Health Organization. WHO Director-General's opening remarks at the media briefing on COVID-19. <https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19-11-march-2020>. Published March 11, 2020. Accessed April 4, 2020.

3. Johns Hopkins University and Medicine. Coronavirus Resource Center. <https://coronavirus.jhu.edu/map.html>. Accessed April 5, 2020.
4. Coronaviridae Study Group of the International Committee on Taxonomy of Viruses. The species severe acute respiratory syndrome-related coronavirus: classifying 2019-nCoV and naming it SARS-CoV-2. *Nat Microbiol*. 2020;5:536-544.
5. Cai J, Sun W, Huang J, Gamber M, Wu J, He G. Indirect virus transmission in cluster of COVID-19 cases, Wenzhou, China, 2020. *Emerg Infect Dis*. 2020;26(6). doi:10.3201/eid2606.200412
6. Wölfel R, Corman VM, Guggemos W, et al. Virological assessment of hospitalized patients with COVID-2019 [published online April 1, 2020]. *Nature*. doi:10.1038/s41586-020-2196-x
7. van Doremalen N, Bushmaker T, Morris DH, et al. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1 [published online March 17, 2020]. *N Engl J Med*. doi:10.1056/NEJMc2004973
8. Lauer SA, Grantz KH, Bi Q, et al. The incubation period of coronavirus disease 2019 (COVID-19) from publicly reported confirmed cases: estimation and application [published online March 10, 2020]. *Ann Intern Med*. doi:10.7326/M20-0504
9. Guan WJ, Ni ZY, Hu Y, et al. Clinical characteristics of coronavirus disease 2019 in China [published online February 28, 2020]. *N Engl J Med*. doi:10.1056/NEJMoa2002032
10. Li Q, Guan X, Wu P, et al. Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *N Engl J Med*. 2020;382:1199-1207.
11. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. 2020;395:497-506.
12. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. *JAMA*. 2020;323:1239-1242.
13. World Health Organization. Report of the WHO-China Joint Mission on coronavirus disease 2019 (COVID-19). <https://www.who.int/docs/default-source/coronaviruse/who-china-joint-mission-on-covid-19-final-report.pdf>. Published February 16-24, 2020. Accessed April 3, 2020.
14. Novel Coronavirus Pneumonia Emergency Response Epidemiology Team. The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19) in China [in Chinese]. *Zhonghua Liu Xing Bing Xue Za Zhi*. 2020;41:145-151.
15. Porcheddu R, Serra C, Kelvin D, Kelvin N, Rubino S. Similarity in case fatality rates (CFR) of COVID-19/SARS-COV-2 in Italy and China. *J Infect Dev Ctries*. 2020;14:125-128.
16. Lippi G, Simundic AM, Plebani M. Potential preanalytical and analytical vulnerabilities in the laboratory diagnosis of coronavirus disease 2019 (COVID-19) [published online March 16, 2020]. *Clin Chem Lab Med*. doi:10.1515/cclm-2020-0285
17. Gautret P, Lagier JC, Parola P, et al. Hydroxychloroquine and azithromycin as a treatment of COVID-19: results of an open-label non-randomized clinical trial [published online March 20,

- 2020]. *Int J Antimicrob Agents*. doi:10.1016/j.ijantimicag.2020.105949
18. Molina JM, Delaugerre C, Goff JL, et al. No evidence of rapid antiviral clearance or clinical benefit with the combination of hydroxychloroquine and azithromycin in patients with severe COVID-19 infection [published online March 30, 2020]. *Med Mal Infect*. doi:10.1016/j.medmal.2020.03.006
 19. Cortegiani A, Ingoglia G, Ippolito M, Giarratano A, Einav S. A systematic review on the efficacy and safety of chloroquine for the treatment of COVID-19 [published online March 10, 2020]. *J Crit Care*. doi:10.1016/j.jcrc.2020.03.005
 20. Cao B, Wang Y, Wen D, et al. A trial of lopinavir-ritonavir in adults hospitalized with severe Covid-19 [published online March 18, 2020]. *N Engl J Med*. doi:10.1056/NEJMoa2001282
 21. Orthopaedic Trauma Association. COVID-19 update. <https://ota.org/coronavirus>. Accessed April 4, 2020.
 22. Royal College of Surgeons. Coronavirus (COVID-19). <https://www.rcseng.ac.uk/coronavirus/>. Accessed April 4, 2020.
 23. Centers for Disease Control and Prevention. Information for healthcare professionals. <https://www.cdc.gov/coronavirus/2019-ncov/hcp/index.html>. Accessed April 5, 2020.
 24. American College of Surgeons. Clinical issues and guidance. Surgical care and coronavirus disease 2019 (COVID-19). <https://www.facs.org/about-acsc/covid-19/information-for-surgeons>. Accessed April 4, 2020.
 25. North American Spine Society. Coronavirus NASS guidance document. <https://www.spine.org/Portals/0/assets/downloads/Publications/NASSInsider/NASSGuidanceDocument040320.pdf>. Accessed April 4, 2020.
 26. Rothe C, Schunk M, Sothmann P, et al. Transmission of 2019-nCoV infection from an asymptomatic contact in Germany. *N Engl J Med*. 2020;382:970-971.
 27. Park J, Yoo SY, Ko JH, et al. Infection prevention measures for surgical procedures during a Middle East Respiratory syndrome outbreak in a tertiary care hospital in South Korea. *Sci Rep*. 2020; 10:325.
 28. Cook TM, El-Boghdady K, McGuire B, McNarry AF, Patel A, Higgs A. Consensus guidelines for managing the airway in patients with COVID-19: guidelines from the Difficult Airway Society, the Association of Anaesthetists the Intensive Care Society, the Faculty of Intensive Care Medicine and the Royal College of Anaesthetists [published online March 27, 2020]. *Anaesthesia*. doi:10.1111/anae.15054
 29. Chee VW, Khoo ML, Lee SF, Lai YC, Chin NM. Infection control measures for operative procedures in severe acute respiratory syndrome-related patients. *Anesthesiology*. 2004; 100:1394-1398.
 30. Rabenau HF, Kampf G, Cinatl J, Doerr HW. Efficacy of various disinfectants against SARS coronavirus. *J Hosp Infect*. 2005;61: 107-111.
 31. Liang ZC, Wang W, Murphy D, Hui JHP. Novel coronavirus and orthopaedic surgery: early experiences from Singapore [published online March 20, 2020]. *J Bone Joint Surg Am*. doi:10.2106/JBJS.20.00236
 32. American Academy of Orthopaedic Surgeons. Policy tracker of telemedicine visits. <https://www.aaos.org/globalassets/about/covid-19/aaos-telemedicine-policy-tracker.pdf>. Accessed April 4, 2020.
 33. American Academy of Orthopaedic Surgeons. AAOS member alert on telemedicine coding. https://www.aaos.org/globalassets/about/covid-19/aaos-coding-guide_covid19.pdf. Accessed April 4, 2020.
 34. American Academy of Orthopaedic Surgeons. COVID-19 telemedicine guidelines. https://www.aaos.org/globalassets/about/covid-19/aaos-telemedicine-resource-guide.pdf?mkt_tok=eyJpIjoiWlRJMFl6ZzBaV114TnpCbSIsInQiOiI2aU50SGhERW1mXC8rTlhnc21welPZlhLQTg0WHFKSis5YzdjaURtWXJPRFNPTHVWVU9mWm9hMU1TVFRRQ1wvK2k1QUhsQ3dZbzVJdHBqU0xQZU0zeW00TWIHMUFw1I1STB1WVINSWxucG5iNWRnbFBsMmI0SUFsZ1wvS1N4QU1cLzcfQ%3D%3D. Accessed April 4, 2020.