Spine Surgery: Precautions and Strategies to Minimize Perioperative Risks Amid COVID-19 Outbreak

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Abstract:

Coronavirus disease 2019 (COVID-19) outbreak is an ongoing pandemic that has shocked the world. It has brought severe socioeconomic disruptions on a global scale that is unprecedented. On the frontline, the medical world is facing mounting pressure and challenges to clinical work. During this escalating worldwide crisis, spine care providers around the world are needing accurate and precise information on how surgical safety for themselves and the patients can be ensured. With the ultimate objective of formulating a standardized work process for spine practices, this article aimed to summarize some key principles from various international recommendations/consensus and combined evidence- and experience-based practice from medical communities around the world.

Keywords:

COVID-19, spine surgery, perioperative precautions

Spine Surg Relat Res 2020; 4(3): 192-198

dx.doi.org/10.22603/ssrr.2020-0076

Introduction

Coronavirus disease 2019 (COVID-19), which is at the center of this pandemic outbreak, is caused by a novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Coronaviruses are enveloped positive-sense RNA viruses with characteristic spikelike glycoprotein projections (S protein)[1]. The virus enters into the host cell to start the infectivity process *via* the spikelike glycoprotein projection which attaches onto the host cell surface receptors. In the case for SARS-CoV-2, the target on human cells is the angiotensin-converting enzyme-2 (ACE-2) receptor which is the same host receptor targeted by SARS-CoV. SARS-CoV, which shares 79.6% of its genomic sequence with SARS-CoV-2[2], is a closely related coronavirus responsible for an epidemic outbreak of severe acute respiratory syndrome (SARS) in 2003. It is now believed that there are seven coronaviruses that can cause disease in humans, most of which are limited to minor cold-like disease. With the addition of SARS-CoV-2 to the list, three (including SARS-CoV and MERS-CoV) have already been considered to be responsible for severe pneumonia and severe acute respiratory syndrome (SARS) in humans[3,4]. As a new emerging virus, there are no known vaccines against it, neither is there any effective antiviral drug available currently that can treat the disease[4,5]. However, several drugs are on clinical trial, one of which is Tocilizumab, a humanized IL-6 receptor antagonist. This drug is thought to work by blocking the cascade of cytokine storm in patients with a severe form of the disease[5].

The first case of COVID-19 was in Wuhan, China, which was reported to the WHO on Dec 31, 2019[6]. Since then, the disease has spread to all continents, except Antarctica, and has affected more than 200 countries and territories. As of May 3, 2020, there are already 3,349,786 confirmed cases and a further 238,628 confirmed deaths[7]. The numbers are nothing short of staggering as is the speed of disease spread. Japan reported its first imported case of COVID-19 on January 16, making it one of the first countries outside China to be affected. Since then, the speed of local community spread proceeded at an alarming rate with Hokkaido, the hardest-hit prefecture in Japan during the early phase of the outbreak. As the situation evolved, the central government decided to place all of Japan under a state of emergency on April 16. As of May 3, 2020, having had a cumulative number of more than 14,839 confirmed cases of infections with a further 492 confirmed deaths, the healthcare system in Japan is facing the mounting threat of being overwhelmed.

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Received: April 26, 2020, Accepted: May 6, 2020, Advance Publication: June 3, 2020

Table 1. Stratification of Spine Conditions Requiring Surgery.

Urgent conditions
1. Severe or progressive neurological deficit due to spinal cord/nerve compression of any cause (e.g., traumatic spinal cord compression, tumor cord compression, cauda equina syndrome, infection such as spontaneous spinal epidural abscess, and postoperative hematoma compression)
2. Spinal cord "at risk" WITH spinal instability due to any cause (e.g., unstable spinal fractures, infection, and tumor)
"Semi-urgent" conditions
1. Spinal cord "at risk" without spinal instability (e.g., cervical/thoracic myelopathy)
2. Persistent symptomatic nerve root compression despite conservative treatment (e.g., symptomatic disc herniation and persistent sciatica in the lumbar spinal stenosis)
3. Spinal infections not responding to conservative management
Non-urgent conditions
1. Nonprogressive degenerative conditions with stable neurological status (e.g., degenerative spondylolisthesis, lumbar spinal stenosis, adult degenerative scoliosis, and adult sagittal Imbalance)
2. Revision surgeries for symptomatic pseudarthrosis
3. Hardware removal for symptomatic implants
4. Nonprogressive deformity conditions (e.g., adolescent idiopathic scoliosis)

Revised from: North American Spine Society. NASS Guidance document on Elective, Emergent and Urgent Spine Procedures and Treatments[9].

This COVID-19 pandemic outbreak has posed serious concerns and challenges to the entire medical community, with no exception of the field of spine surgery. Various international medical organizations have published guidelines and recommendations[8-10], most of which recommend general precautions and curtailing of elective surgeries. Spine surgery is unique in its field owing to some pathologic conditions being time-sensitive and requiring emergency/urgent surgery so as to prevent devastating neurological sequelae. However, when treating this subgroup of spine patients requiring emergency procedures, the threat of disease spread is still a major concern for spine care providers. Although much has been written on the basic property and clinical features of the virus itself, articles on the practical aspects of surgical safety specific to the field of spine surgery remain scarce. Currently, we are also not aware of any written guidelines or consensus within the spine community of Japan. This article aimed to discuss the adversities faced by spine care providers during this COVID-19 pandemic outbreak and to provide some guiding principles as to how spine specialists can respond in providing safe optimum care to our patients under these very challenging circumstances without compromising the safety of the entire healthcare team.

Basic Principles

The basic principles revolve around a few concepts: "Early Detection," "Early isolation," "Effective and efficient resource conservation," "Timely surgery," and "Surgical safety for both patients and surgeon"[11]. Among the consensus/recommendations[8-10] that have been available so far, the National Health Service (NHS) of the United Kingdom (UK) published a set of clinical guidelines that can prove useful in managing spine patients during this pandemic on March 20, 2020[10]. Some useful concepts include the establishment of an early disease response system in the local/region according to the extent and severity of the outbreak situation in that area so that a "common language" is spoken within the medical community.

Next, the potential for irreversible neurological sequelae in certain "time-sensitive" spinal conditions makes it necessary to stratify patients based on the urgency of treatment required (Table 1). For urgent spinal conditions, surgery on an urgent/emergent basis should proceed to salvage or preserve neurological functions[10-12]. On the other hand, non-urgent conditions should be postponed or cancelled. A group of conditions which are considered "semi-urgent" remains, where most spine surgeons would agree on early surgical intervention under normal circumstance. In the context of this ongoing pandemic outbreak, the degree of urgency is subjective to a certain extent. The decision to continue with surgical intervention should be weighed against the risk of disease transmission and logistical considerations (hospital bed shortages, critical care availability, manpower adequacy, and availability of resources). As the situation evolves, the above preliminary stratification used in conjunction with a local/regional directive, such as the one used by the NHS, can serve as a guide for spine surgeons in prioritizing patients' treatment. The potential benefits are better management of workload and conservation of resources, such as hospital beds, critical care capacity, medical equipment, and manpower, in accordance to local/regional directions.

Outpatient Management

In the current situation, the principles of managing outpatient/first contact clinics should focus on the reduction of unnecessary hospital attendances while maintaining continuity of care for patients with spinal disorders. A consultant-led role, supported by a multidisciplinary team, is critical in screening the list of outpatient cases in order to reduce the number of hospital attendances. Routine follow-up cases should be cancelled or rescheduled. Many countries have

implemented a lockdown (partial or complete) policy as a sort of "circuit breaker" to this pandemic outbreak. As the "lockdown" continues, with no end in sight, the issues we anticipate in this group of patients include the following: shortage of prescription-only medications, anxiety with regard to persistent symptoms, and concerns with postsurgical wound care. We think it might be useful to involve various allied health professions in the planning of a workflow during this pandemic crisis. Prescription for common medications in spine patients, such as pain medications, anti-inflammatory drugs, and antibiotics) can be made obtainable *via* open-access email/telephone number. These also serve as a portal for patients to communicate to pharmacist/doctors their medication requests and specific spine condition-related queries. Internet-based or televideo-conference consultation with doctors for both routine follow-up and first contact cases can be considered.

Patients with deterioration of condition or first contact cases with spine pathologies that warrant urgent/emergent workup should proceed with face-to-face consultation albeit under a safe environment. The hospital should have a well-thought-out workflow in achieving the primary objective of reducing hospital-related disease transmission. Ideally, all patients visiting the hospitals should be triaged and undergo mandatory screening for COVID-19 at the doorsteps or at a special filter area. These include risk assessment questionnaire (including travel history), provision of details on the place of residence (for contact tracing), and doorstep temperature screening. Patient attendance should be restricted to the least possible number - patients already identified by the leading consultant. Scheduling of doctor consultation should be adequately spaced apart to reduce overlapping appointments so as to lessen contact time with other patients. Patients are required to abide by strict punctuality to avoid encroaching on other patients' "time slot." The waiting area should be kept spacious with 1-2 m separation between patients and regularly sanitized. Ideally, healthcare workers attending to these patients should be adequately protected with personal protection equipment (PPE) during the consultation, as studies have shown that 17.9% to more than 50% of patients infected with SARS-CoV-2 are asymptomatic carriers[13-15].

Inpatient Management

The fundamental principle in managing inpatients centers on how we can continue safe provision of healthcare services to spine patients, especially those who need surgical intervention (emergent or urgent elective), while minimizing the spread of disease. Hospitals designated to treating patients with COVID-19 should have adequate means to isolate infected and suspected cases from uninfected patients, as well as sufficient critical capacity, healthcare staff, and PPE to cope with the expected escalation in the number of cases.

A well-thought-out, systematic preparedness plan[16], such as the one developed by Centers for Disease Control and Prevention, can help acute care facilities adjust their workflow for emergency situations. The concept of "zoning" or "distancing" in order to reduce contact time and maintain distance barrier between patients should be borne in mind while making these policy alterations. All patients attending the emergency department who require inpatient hospitalization should be triaged at the "doorsteps." The choice of screening tool is still a subject of much debate. The detection of viral nuclei acid with reverse transcription polymerase chain reaction (RT-PCR) test is the commonest screening tool adopted by most countries. However, with reports of varying sensitivities (37%-71%)[17] and high false-negative rates (more than 21%)[18,19], questions have been raised on the reliability of currently available RT-PCR tests and the criteria for a true negative test. Most countries use two consecutive negative RT-PCR tests as the cutoff for diagnostic as well as the discharge criteria for suspected patients. Chest CT scan has also been suggested as an alternative screening tool owing to the presence of pneumonic changes in early infection (even in asymptomatic patients)[20,21] as well as superior sensitivities compared with the RT-PCR test (98% vs 71%)[17]. However, experts remain divided on the routine practice of using chest CT scan as a screening test[22,23].

Specific to the management of patients with possible emergency spine pathologies, a dedicated specialist triage team led by a spine consultant will provide the support in the triage and assessment of spine patients[10]. Ideally, suspected or infected patients should be isolated in a separate isolation ward and looked after by an assigned team of nursing staff. Investigations, such as CT, MRI, or plain radiographs, should be planned in such a way that patients are strictly time-slotted with adequate intervals between each inpatient to reduce contact time and also follow proper sanitization protocol. Patient movements within the hospital need to be thought out meticulously to ensure "clean" route for the uninfected as is the need to cordon off areas reserved only for intra-hospital transfer of suspected/infected patients. Ideally, in order to minimize transmission between healthcare workers, hospital staff may need to be segregated into two groups (at least), with one team dedicated to looking after confirmed cases of COVID-19 and the other team looking after uninfected individuals. Healthcare workers involved in providing care to patients should adhere to the infection control protocols established by their institute. Refresher courses on the proper techniques of handwashing, PPE donning and doffing, etc., should be conducted for all healthcare workers.

Preoperative "Second Triage" for Risk Stratification

Since the pandemic started, the formulation of a set of recommendations has been the urgent priority. Some preliminary consensus and recommendations have been published by various organizations[8-11,24-26]. The common theme is

Table 2. Second Triage Process.

1) Preoperative systematic review by anesthetist - focusing on respiratory symptoms.
2) Re-screening patient's temperature for fever.
3) Mandatory plain radiograph of the chest.
4) Routine preoperative blood tests: full blood count, renal panel, C-reactive protein (CRP).
5) Recent computed tomography scan of the chest (within 24 h) for lung changes.
6) Repeat RT-PCR test.

cancellation of elective surgeries, focusing only on emergency procedures. The main concern, however, is surgical safety in patients with time-sensitive spine conditions, whereby urgent surgical intervention is needed. When a patient infected with SARS-CoV-2 requires spine surgery, the risk of perioperative disease transmission from the patient to the entire surgical team (anesthetist, nurses, and the surgical team itself) is a major concern. It has been reported that patients with COVID-19 who require surgery are at a greater risk of perioperative complications[27]. Lei et al.[27] observed significantly higher morbidity and mortality rates (20.6%) in this group of patients when compared with COVID-19 patients without surgery (2.3%) and surgical patients without COVID-19 who require postoperative ICU care following non-cardiac surgery (7.9%). Surgical stress during the incubation period/early phase of infection can exacerbate the progression and severity of disease (COVID-19). We propose a preoperative "second triage" (Table 2) for all patients requiring spine surgery with the aim of identifying possible infected cases (even asymptomatic ones) to better manage perioperative risks to both patients and surgeons[24].

The rationale for repeating the screening process is logical, although not 100% fail-safe due to reported high false-negative rates[17-19] with the RT-PCR test. This false-negative percentage can be decreased with repeat testing. A recent (within 24 h) chest CT scan as an adjunctive screening tool is also advocated for patients undergoing emergency surgeries[26]. The use of serum antibodies (immunoglobulin G and M) has also been proposed to detect SARS-CoV-2 virus. The results of two recent studies on serum antibody response suggest that it (anti-SARS-CoV-2 IgM and IgG seroconversion) can be used as a complementary assay test to RT-PCR, especially in the subacute or chronic phase of the disease[28,29]. However, its utility in detecting the disease during the acute phase as well as in patients with milder forms of infection is limited by its temporal characteristics and variable seroconversion rates between different individuals[28,29]. In a situation wherein a patient who tested positive for COVID-19 requires urgent spine surgery, it is best to seek the advice of the infectious disease specialists early prior to surgery.

Perioperative Risks and Strategies for Risk Management

Perioperatively, the main concern centers on the risk of disease transmission from aerosol generation during the induction/intubation process[11,24,30,31]. During spine procedures, aerosol generating procedures (AGPs) and electric-powered devices are the main source of aerosol and surgical smoke, respectively. The use of high-powered electric tools, such as burr, drills, and oscillating saws, in spine surgery can result in the formation of aerosol particles. Studies have demonstrated live viruses (e.g., influenza virus and human immunodeficiency virus [HIV]), bacteria, and viable cells in cold aerosols produced during AGPs[32-35]. The use of energy-powered equipment, such as electrocautery devices, during the surgical exposure of the spine (e.g., monopolar/bipolar diathermies) also leads to the generation of surgical smoke containing particles of varying sizes[33,36]. The number and size of particles being directly related to the energy level and the duration of usage of these devices with smaller-sized particles most likely to travel further in the air[36]. The presence of bacteria and DNA viruses, such as HIV and human papilloma virus,[33,35,37] in surgical smoke has been reported; however, the significance of these findings in the context of surgical risk to surgeons remains unclear. Although the evidence is not strong, the most cited case report has demonstrated spine surgeons contracting this disease after operating on infected patients as a sufficient proof that surgical smoke and disease transmission to surgeons are related[38].

Should a patient with COVID-19 require urgent spine surgery, various precautionary measures have been recommended (Table 3). Some strategies aimed specifically at reducing the risk of spine surgery in patients with COVID-19 have been suggested[11]. The selection of spine procedures should be based on the techniques that facilitate the desired surgical outcome with the quickest and safest means. Spine surgeons should exercise caution when performing procedures that require the use of bulky equipment in the operating room (OR), such as the O-arm, as such equipment are difficult to disinfect after surgery. The modification of surgical techniques to limit the number of personnel and equipment should be considered. Minimally invasive surgical (MIS) approaches, such as percutaneous approach to pedicle screw insertion, and even endoscopic spine techniques can be used to reduce the time to use electric-powered surgical tools. The use of MIS or percutaneous endoscopic spine approaches is advantageous over open approaches for the following reasons: 1) faster recovery time allowing faster turnover of hospital beds; 2) reduced blood loss and lesser risk of disease transmission *via* large droplets; and 3) specific MIS procedures, such as percutaneous pedicle screw stabili-

Table 3. General Perioperative Precautionary Measures.

Logistical measures
1. Adequate protective equipment (PPE, N95 masks)
2. Adequate manpower
3. Staff training in proper "donning and doffing" of PPE and N95
4. Induction room and OR with negative-pressure ventilation and high efficiency
5. Dedicated OR with clear labels and signs
6. High-efficiency particulate air (HEPA) filter
Anesthetic precautions
1. Restricted access to induction room/OR only to personnel involved in the surgery - assisting nurse, surgical team, and anesthetist team
2. Intubation to be performed by the anesthetist wearing full PPE and N95 mask
3. Post-intubation 30-min restricted access only to anesthetist and anesthetist assistant
4. Rapid sequence intubation
5. Avoidance of high-flow nasal cannula oxygen and NIV
6. Postoperative recovery in OR/induction room
Postoperative measures
1. Decontamination of OR/induction room as per hospital infection control policy
2. Disinfection at least 30 min
3. Change of high-efficiency particulate air filter and air supply closure
4. 2-h turnover wait before OR is ready to receive the next patient
5. Isolation ward for postoperative recovery
6. Dedicated transfer route to the isolation ward
7. Co-management with the Infectious Disease Unit for medical therapy, de-isolation, etc.

zation, having less electrocautery dissection of the soft tissues so as to reduce the harms of aerosols and surgical smoke compared with open stabilization. The indications for endoscopic spine surgery continue to expand over the last two decades, as well as the successful treatment of various emergency/urgent conditions, such as epidural abscess causing neurological deficits in patients with spinal infections[39]. Unlike concerns of pneumoperitoneum aerosol with MIS procedures in general surgical procedures, such as laparoscopic abdominal surgery[40], percutaneous endoscopic spine procedures do not require air insufflation. One paper[11] recommended avoiding lateral or supine position spine surgery access for COVID-19-infected patients, preferring posterior access surgery, because droplets would tend to fall to the floor in the OR.

Spine surgery should be performed with the surgical team wearing full PPE and N95 mask[41]. Based on their experience in Italy, the IRCCS Istituto Ortopedico Galeazzi, Milan, included the additional practice of triple gloving and double gowning (one water barrier gown and an outer sterile gown) in their protocol for surgical preparations when operating on an infected patient. The author advocated a third layer of glove for safety purpose during the "doffing" of PPE after surgery[42]. Surgical preparation should proceed as per the standard aseptic protocol with the aim of reducing surgical site infection[43]. It has also been suggested that the use of disposable drapes or equipment is preferred for the purpose of infection control[44]. During the surgical exposure of the spine, unnecessary use of AGP devices, as well as energy-powered devices, should be avoided. When required, electrocautery devices should be set to the lowest possible energy setting. The use of local exhaust ventilation devices or suction, placed within 2 in from the surgical field, should be considered, as a recent study demonstrated that the use of local smoke evacuators can decrease average smoke level (by 44.1% to 59.7%) and significantly reduce peak smoke level during the surgical exposure of the spine[45]. The Centers for Disease Control and Prevention (CDC) also recommends filtered central wall room suction units together with local exhaust ventilation device and N95 mask to reduce exposure to surgical smoke[46,47].

Postoperative Management

During the extubation process, the doors to the OR should remain closed, and the patient should be recovered in the OR. The OR team needs to observe strict decontamination protocol before leaving the induction room/OR. This includes the correct sequence of PPE "doffing" and observation of general precautions, such as proper hand hygiene. After the OR staff and surgical team have left, decontamination of the OR and induction room should follow proper decontamination policies. Postoperative disinfection of the OR should be performed using detergent and water, followed by the use of 1000 ppm bleach solution for all hard surfaces in the OR[48]. The high-efficiency particulate air (HEPA) filter should be changed and the air supply closed. The recommended disinfection time is at least 30 min, and the OR room should be closed for at least 2 h after laminar air flow and after the ventilator is turned on.

Infected patients who just underwent spine surgery should be transferred to the isolation ward/room, and postoperative

care should be provided by infectious disease specialists. Supportive treatment in the form of supplemental oxygen, nebulization, and hemodynamic support should be administered if needed. De-isolation should be performed according to the de-isolation protocols of the institution and after consultation with the infectious disease specialist. For postoperative patients (previously not known to have COVID-19) who developed fever and respiratory symptoms, a RT-PCR test and chest CT scan should be performed[48] to confirm the diagnosis of COVID-19, and patients should be monitored closely for the development of respiratory distress syndrome.

Conclusion

Since its emergence last year, the COVID-19 global pandemic has presented serious challenges, not just to the medical community but also to humanity in general. New cases are still reported daily and countries are finding themselves increasingly stressed on all fronts. At the time of writing, Japan is already 2 weeks into a government-declared state of emergency. With no indication that the situation is abating, an immediate response is required. The principles mentioned above are by no means exhaustive, and as the situation evolves, addition or even alterations to the said measures are expected. Some of the points raised are very relevant to our practice and can serve as a guide for strategies that our spine colleagues can adopt. The COVID-19 global pandemic is not the first outbreak crisis that the world has faced, and it certainly will not be the last. A consensus on the best evidence-based practice can provide perspective on how we, as spine surgeons, can better handle a similar medical crisis in future.

Disclaimer: Manabu Ito is one of the Editors of Spine Surgery and Related Research and on the journal's Editorial Committee. He was not involved in the editorial evaluation or decision to accept this article for publication at all.

Conflicts of Interest: The authors declare that there are no relevant conflicts of interest.

Author Contributions: Tzong-Jing Victor Wang took the lead in conducting literature review as well as the drafting and writing of the manuscript.

Manabu Ito provided critical feedback to every draft copy as well as the co-writing of the manuscript.

Both authors were involved in the conception of this study as well as revision of every draft.

Informed Consent: Not applicable

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