Safe Spine Surgery During the COVID-19 Pandemic

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Abstract: Safe spine surgery is possible during the COVID-19 pandemic. Certain urgent procedures must still be performed during this challenging time to prevent permanent long-term disability or death for patients. Precautions must be taken in the operating room to optimize safety, including the use of personal protective equipment and appropriate room setup and anesthesia and equipment optimization. Evidence-based guidelines to create a safe operative paradigm for use in future viral outbreaks are paramount.

Key Words: spine surgery, COVID-19, safety, N95, surgical plume, antibody testing, virus, ventilation, guidelines

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OVERVIEW

The novel coronavirus 2019 (COVID-19) pandemic has altered the standard of care for spine surgery in unprecedented ways. Broad recommendations to cancel, delay or limit surgical procedures were made in the early phases of the disease spread to divert and preserve resources for infected patients, and there remains no obvious and safe timeline for when these restrictions can be relaxed or lifted.[1–11]

Nonetheless, certain urgent procedures must still be performed during this challenging time to prevent permanent long-term disability or death for patients. Spine surgeons are among the few groups continuing to perform urgent surgeries because of infections, trauma, intractable pain, and neurological deterioration. When surgical intervention is deemed critically necessary and an institution approves the surgery to proceed, a comprehensive and multidisciplinary plan must be undertaken to maximize the safety of that procedure.

Intraoperative safety for the spine surgeon during this epidemic is of paramount importance. Rates of COVID-19 infection of orthopedic surgeons in China have been as high as 20%.[12] Spine surgeons are uniquely poised to demand certain precautions and modifications immediately before, during, and after the procedure to protect themselves and their interdisciplinary surgical team while providing high-quality care. We present here an evidence-based protocol to improve the safety of spinal surgery during the COVID-19 pandemic and for use during future infectious disease outbreaks. This protocol also reflects the experience of the coauthors from their own surgical cases during this period.

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PART I: CURRENT RECOMMENDATIONS FOR SURGERY DURING COVID-19

Standard protocols have been developed for performing a surgical procedure on a COVID-19-positive patient.[1–3,7,13–15] These protocols entail optimizing operating room (OR) location, ventilation, and ensuring a safe area to don and doff personal protective equipment (PPE).[1–3,7,13–15] Although precautions must be taken for provider protection, the specific concerns do vary based on the type of surgical procedure performed. For example, certain otolaryngology procedures present a much higher exposure risk than emergent caesarian sections.[13,14]

Orthopedic surgeons have made recommendations regarding conserving resources, delaying, or canceling nonemergent surgeries, and protecting providers and staff through PPE and sequestration of surgical teams from exposure.[4,9,10,16–18] It should be noted that some of these guidelines are not evidenced based, as we do not yet have data on the consequences of delayed surgeries during this pandemic.

PART II: CURRENT RECOMMENDATIONS FOR SPINE SURGERY DURING COVID-19

Current recommendations for the practice of spine surgery during the COVID-19 pandemic are limited. Spine-related concerns can be triaged, telemedicine may be utilized to limit in-person exposure, and inasmuch as possible, COVID-19-specific ORs may be utilized.[9,19–22] In general, most recommendations currently reserve surgical intervention for patients with acute nerve compression, spinal cord injury, progressive neurological deficits, unstable traumatic fractures, or when further delay risks neurological deterioration.[4,5,19–21,23] These guidelines are admittedly broad and in practice, each institution is placing its own restrictions on which cases can be performed urgently based on state restrictions, the hospital's current resources, and the COVID-19 admission burden.[8] The ability to accommodate surgical volume in addition to COVID-19 admission volume varies regionally and depends on the number of COVID admissions in each state at any given time. Each state and hospital must unfortunately weight the

risks and benefits moving forward when deciding when, and to what extent, to permit cases to proceed.

In Singapore, during the early months of the outbreak (February–March 2020), many orthopedic surgeries continued including cases not requiring admission (arthroscopies, removal of hardware and soft tissue procedures) and trauma and tumor cases.[16] Spine cases were limited to minimally invasive and endoscopic cases not expected to have significant operative times or blood loss.[23] Elective, nonurgent spine procedures requiring admission were delayed, focusing instead on continued nonoperative management with injections and other interventions.[16,23] No comprehensive recommendations currently exist for intraoperative protocols for spine surgery during this unique time.

PART III: PERIOPERATIVE CONSIDERATIONS FOR THE SPINE SURGEON

Preoperative Planning

The COVID-19 status of any surgical patient is an integral component of providing safe spine surgery during an outbreak. Currently, the virus can be detected by nasopharyngeal swab or bronchoalveolar lavage polymerase chain reaction rapid testing for the SARS-CoV-2 genetic material. Some systems are able to test patients for COVID-19 anywhere from 2 to 28 hours preoperatively. However, as the false-negative rates are not well known for the currently available tests, universal precautions must be followed. In addition, a positive test result does not always allow for delay or cancellation of a procedure, instead of providing confirmation that the strictest protocols for safety must be followed. In addition, patients should remain quarantined until their test result is finalized.

Where possible, the spine surgeon should encourage preoperative testing of patients, as spine procedures are considered "high risk" as defined by the highest risk factors for COVID-19 transmission during procedures: required intubation/extubation, prolonged length of procedure, and handling of blood and bodily fluids. Recent research from the asymptomatic transmission period of the COVID-19 outbreak has suggested that patients with undiagnosed COVID-19 who were scheduled for elective surgery suffered a more severe and deadly disease course because of the surgical intervention.[24,25] Twenty percent of these patients died postoperatively compared with the 2%–5% mortality rate of the disease overall, indicating that the physiological burden of surgery is high for these patients.[24] Therefore, until antibody testing is accurate and widely available, preoperative polymerase chain reaction testing is crucial for identifying at-risk patients who may seem clinically well and for protecting both the surgical team from exposure and limiting harms to the patient.

OR Setup

Protocols for the appropriate setup of an OR for COVID-19-positive patients have been published from the early experiences in China and from past experiences with the SARS virus.[26,27] Hospitals must establish a negative-pressure operating room with appropriate ventilation systems and equipment that remains within the COVID-19-assigned room at all times.[26,27] Standard positive-pressure operating rooms allow for the constant removal of contaminated air away from the surgical field, whereas negative-pressure rooms prevent the removal of contaminated air to protect the outside environment from contagion.

Recent studies of coronaviruses have indicated that they can live on metal, glass, or plastic surfaces for up to 9 hours, necessitating surface disinfection with 62%–71% ethanol, 0.5% hydrogen peroxide, or 0.1% sodium hypochlorite.[11] Reusable instruments and trays will require an appropriate level of disinfectant after any case with concern for COVID-19. Disposable instruments should be used whenever possible in these scenarios. Equipment and instrumentation trays should be opened immediately before the start of the surgical case to prevent any further contamination of the equipment during patient transfer into the OR and intubation.

PPE

Baseline PPE for COVID-19 includes a fluid-resistant gown, gloves, eye protection, full face shield, and an N95 respirator.[28] Most of this equipment is standard required PPE for any surgical case, however, use of a full face shield or an N95 respirator is not standard practice for many surgeons. In the event of a positive patient undergoing surgery, a face shield and an N95 must be worn by all providers in the OR as N95s provide filtration of the droplet and airborne particles that are not filtered by all standard surgical masks. Without any concern for COVID-19, there are no recommendations that an N95 should be worn during a surgical case; a standard surgical mask meets protective standards for surgical cases without airborne infectious concerns.

Powered air-purifying respirators have the ability to provide a greater level of protection than an N95, however, data are mixed on whether they decrease airborne viral transmission in any meaningful way.[11] These hooded respirators do confer face shield protection and can be more comfortable than an N95 for many surgeons, without requirements for fit-testing or specific compatible facial hair.[11] However, these respirators are expensive and do not necessarily confer any additional safety benefits.[11] These respirators must be distinguished from the commonly used "surgical helmet systems" used during total joint arthroplasty. These helmets are not necessarily designed to provide respiratory protection for the provider and must be confirmed by one's institution and/or the manufacturer as an appropriate alternative to a respirator before being used.

Lead aprons and goggles should be able to be worn underneath protective gowns and face shields when operating on a COVID-19-positive patient, and protection from radiation need not be sacrificed in these situations.

Neuromonitoring

Spinal surgery often requires intraoperative monitoring of neurological status. Neuromonitoring necessitates the placement subdermal needles in various locations on the body,

exposing the technologist placing the needles to the risk of blood-borne pathogens. A technologist is present in the OR to set up the equipment and monitor during the procedure, with a clinical neurophysiologist generally observing the results remotely.

In an effort to limit staff exposure in the OR, the necessity of neuromonitoring itself should be considered. If required, the technologist may be able to be physically present in a sequestered area of the room for the lowest possible exposure to the surgical environment.

Visitors to the OR

The operating theater historically has allowed for the attendance of additional observers both for technical support and educational benefit. Technical representatives for instrumentation and equipment companies are an integral part of optimizing patient care in the OR. However, during this era of the continued risk of exposure, it would be advisable to recommend that those individuals remain outside of the OR during the procedure and can be reached by telecommunication on an as-needed basis for technical concerns and be available to come into the room as needed should any issues arise. In addition, educational observers are not recommended in the OR, particularly during a high-risk case.

PART IV: INTRAOPERATIVE CONSIDERATIONS FOR THE SPINE SURGEON

Anesthesia and Intubation/Extubation Concerns

Intubation and extubation are the highest risk moments for COVID-19 transmission during spine surgery. Based on the known characteristics of airborne and droplet transmission of the virus, any procedure that produces additional aerosolized viral droplets is considered high risk. Therefore, it has become standard protocol at the coauthor's institutions that all staff besides the anesthesia team exit the room during intubation and extubation and for 10–15 minutes afterward during which the particles are thought to remain airborne (minutes of time determined by the frequency of air exchange per hour based on room airflow).

In addition, the use of a high efficiency particulate air filter connected to the patient's breathing tube and an additional filter between the expiratory limb and the anesthesia machine is recommended by many.[11] Rapid sequence induction should also be performed to avoid the need for manual bag-mask ventilation and deep anesthesia with a complete neuromuscular block is recommended before intubation to prevent coughing/bucking.[11] Minimizing disruptions in the circuit is also recommended.[11]

Intraoperative Tools

Electrocautery and high-speed burrs are used frequently in spine surgery, whereas intraoperative lasers can be utilized in some spine tumor cases. Electrocautery is necessary to limit intraoperative blood loss during the surgical approach and identification of active bleeding, whether through the use of traditional electrocautery or bipolar hemostatic sealer.[29] Historical data have identified the risk of exposure to bacterial and viral material in the OR because of surgical smoke plume for both electrocautery and laser use.[30–33] Smoke evacuators are recommended as the standard of care for reducing the surgical plume and are already in use at many large medical centers.[30–32] Data on COVID-19 in the surgical plume are not yet available, but recent data suggest that viral particles can be aerosolized and transmitted in closed environments and that viral ribonucleic acid is found in blood and other bodily fluids.[34,35] Concern for aerosolization of COVID-19 viral material in the surgical plume should remain high and ultra-low particulate air filter evacuation systems should be utilized, which remove particulates as small as 0.1 μm.[33] Suction waste-management systems may assist in high suction, integrated smoke evacuation, and safe sequestration of surgical suction materials and have been used by the coauthors for added protection.

Intraoperative high-speed burring results in large amounts of tissue debris with both droplets and an aerosol cloud that have been found to contain microbial contamination.[36–38] Studies of the extent of material exposure during high-speed burring during cervical spine surgery have indicated that the entire room and all personnel are completely contaminated with material to an extent of 5×7 m.[39] This measurement suggests a theoretical 5×7 m space centered around an OR table. Therefore, a high-speed burr should be considered a high-risk tool for aerosolization of COVID-19 viral material and additional PPE would be recommended for all individuals in the OR in a COVID-19-positive or COVID-19 rule-out patient.

Fluoroscopic Equipment

The intraoperative use of fluoroscopy is required during most spine surgeries in the form of fluoroscopic x-ray, computed tomography (CT or C-arm), or intraoperative 3-dimensional imaging (O-arm). AORN guidelines require that imaging be draped in a sterile manner before entering the surgical field.[40] The image intensifier is draped in a plastic drape that allows for the machine to move from posterior-anterior images to lateral images without loss of sterility. The x-ray tube of the machine is unsterile for posterior-anterior imaging as it resides under the table, but it requires coverage for lateral images with either a temporary sterile drape or the use of a reusable and expandable drape. O-arm use requires a sterile drape to be placed over the body of the arm as well.

Intraoperative fluoroscopic equipment is routinely wiped down with germicidal wipes described as "effective against bacteria, viruses, fungi, yeasts, methicillin-resistant staphylococcus aureus, tuberculosis, HIV-1 (AIDS), and hepatitis B. Meets Environmental Protection Agency and Occupational Safety Health Administration standards." There is no known information available on whether these standardly use wipes are effective against COVID-19. Intraoperative machines are reused for other cases sometimes within minutes of their prior use with only a brief wipe-down in between. There is concern that these machines could be a source of transmission of viral material

from the surgical field, despite their sterile draping as it is limited to only part of the machine.

Data from a major radiology department in the Sichuan province of China found that a specific surface disinfectant protocol for their CT scanner contributed to the ability to screen over 7000 patients for COVID-19 without a single infection in a radiology technician.[41] The CT machine was disinfected with 1000 mg/L chlorine-containing disinfectant and wiped twice with 75% ethanol for noncorrosive surfaces every 4 hours. The Environmental Protection Agency has determined a series of other surface disinfectants that are effective against COVID-19.[42]

We propose that a similar protocol be used for intraoperative imaging at the end of a spine surgery case as the machine is often in use for hours at a time. The machine should not enter and exit the room during a case if possible. If required, the machine should be sterilized upon exit and re-entry.

PART V: IMMEDIATE POSTOPERATIVE CONCERNS FOR THE SPINE SURGEON

Postoperative Recovery

Intensive care unit (ICU) utilization during the COVID-19 pandemic is a top priority for every hospital system and has required changes to the standard admission criteria for ICU-level care.[43] The creation of COVID-19-positive ICUs or areas within a unit is the standard practice, however, it is not always possible.[43] In addition, mixed units place postoperative surgical patients and their postoperative surgical teams at risk of exposure. Therefore, it is recommended that patients who require postoperative ICU care after spine surgery have a plan in place for transfer to a sequestered until that can provide intensive care and monitoring without COVID-19 exposure.

The utilization of intensive care resources should be reserved for those patients with the greatest need. Communication about requirements for frequent neurological examinations or mean arterial pressure goals postoperatively may allow an ICU to divert that patient to a step-down unit that can still appropriately manage those critical goals. Additional consideration may be needed for patients not requiring ICU care, but who require the use of nebulizer treatments or continuous positive airway pressure for sleep. These treatments also present the risk of airway secretion aerosolization and a negative-pressure ventilation room should be considered.

CONCLUSIONS

Safe spine surgery is possible during the COVID-19 pandemic. Certain precautions must be taken in the OR to optimize safety, including use of PPE, appropriate room setup, and anesthesia and equipment optimization. Spine surgeons are in a unique position to provide necessary emergent care to patients during this unprecedented time and evidence-based guidelines to create a safe operative paradigm for use in future viral outbreaks are paramount.

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