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## Does Coronavirus Disease 2019 (COVID-19) Affect Perioperative Morbidity and Mortality for Patients Requiring Emergency Instrumented Spinal Surgery? A Single-Center Cohort Study

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■ **BACKGROUND:** The coronavirus disease 2019 (COVID-19) pandemic sent shockwaves through health services worldwide. Resources were reallocated. Patients with COVID-19 still required instrumented spinal surgery for emergencies. Clinical outcomes for these patients are not known. The objective of this study was to evaluate the effects of COVID-19 on perioperative morbidity and mortality for patients undergoing emergency instrumented spinal surgery and to determine risk factors for increased morbidity/mortality.

■ **METHODS:** This retrospective cohort study included 11 patients who were negative for COVID-19 and 8 patients who were positive for COVID-19 who underwent emergency instrumented spinal surgery in 1 hospital in the United Kingdom during the pandemic peak. Data collection was performed through case note review. Patients in both treatment groups were comparable for age, sex, body mass index (BMI), comorbidities, surgical indication, and preoperative neurologic status. Predefined perioperative outcomes were recorded within a 30-day postoperative period. Univariable analysis was used to identify risk factors for increased morbidity.

■ **RESULTS:** There were no mortalities in either treatment group. Four patients positive for COVID-19 (50%) developed a complication compared with 6 (55%) in the COVID-19–negative group ( $P > 0.05$ ). The commonest complication in

both groups was respiratory infection. Three patients positive for COVID-19 (37.5%) required intensive care unit admission, compared with 4 (36%) in the COVID-19–negative group ( $P > 0.05$ ). The average time between surgery and discharge was 19 and 10 days in COVID-19–positive and –negative groups, respectively ( $P = 0.02$ ). In the COVID-19 positive group, smoking, abnormal BMI, preoperative oxygen requirement, presence of fever, and oxygen saturations  $<95\%$  correlated with increased risk of complications.

■ **CONCLUSIONS:** Emergency instrumented spinal surgery in patients positive for COVID-19 was associated with increased length of hospital stay. There was no difference in occurrence of complications or intensive care unit admission. Risk factors for increased morbidity in patients with COVID-19 included smoking, abnormal BMI, preoperative oxygen requirement, fever and saturations  $<95\%$ .

### INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic sent shockwaves to global health care systems. First reported in Wuhan City China in December 2019, the virus genome was rapidly characterized.<sup>1</sup> High virulence and global travel created new epicenters in Europe, Asia, and America. By June

#### Key words

- Clinical outcome
- Cohort study
- COVID-19
- Emergency
- Instrumented spine surgery (ISS)
- Major trauma center (MTC)

#### Abbreviations and Acronyms

- BMI:** Body mass index
- CT:** Computed tomography
- ICU:** Intensive care unit
- MTC:** Major trauma center
- NHS:** National Health Service

**RT-PCR:** Reverse transcriptase-polymerase chain reaction

**SARS-CoV-2:** Severe acute respiratory syndrome coronavirus-2

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2020, 10 million cases had been identified in more than 200 countries, and most soberingly of all, 500,000 people had died.<sup>2</sup>

The World Health Organization declared the COVID-19 outbreak a global health emergency and advised resources be redirected to treat patients with COVID-19 and medical emergencies. In March 2020, the United Kingdom's National Health Service (NHS) announced immediate cessation of all nonurgent elective surgery and commenced an ambitious building program for new hospitals, The NHS Nightingale Project, to increase capacity.<sup>3</sup>

Early in the pandemic reports started to emerge of high morbidity and mortality in patients infected with COVID-19 who underwent surgery.<sup>4,5</sup> There was a lack of testing equipment in many countries, and tests were prioritized for the sickest. Results in these early studies may therefore have been confounded. There are very few studies reporting perioperative outcomes for patients with COVID-19 who undergo surgery, and no studies reporting outcomes for patients with COVID-19 who undergo emergency instrumented spinal surgery. The lockdown in many countries reduced the incidence of patients requiring emergency instrumented spinal surgery and so requirement was less.

In certain circumstances, emergency instrumented spinal surgery is justified in patients with COVID-19 as the alternative may be worse.<sup>6</sup> Delays to operative intervention may result in greater morbidity and mortality for patients.<sup>7-9</sup> The Royal London Hospital is the United Kingdom's busiest major trauma center (MTC), situated in East London at the heart of the U.K. outbreak. This made it uniquely possible to analyze the results of emergency instrumented spinal surgery for patients with COVID-19 during the pandemic.

The primary objectives of this study were to establish the effects of COVID-19 on perioperative morbidity and mortality in patients undergoing instrumented spinal surgery, and to determine risk factors for any increased morbidity and mortality. Secondary objectives were to determine differences between patients positive for COVID-19 and patients negative for COVID-19 in postoperative complications, admissions to the intensive care unit (ICU), and duration of hospital admission.

## METHODS

We used the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist for this section of the manuscript.<sup>10</sup>

### Study Design

This retrospective observational cohort study included consecutive patients undergoing emergency instrumented spinal surgery in one NHS hospital in the United Kingdom. No ethical approval or informed consent was required for this study, it was registered as a service evaluation through the local hospital governance team.

### Setting and Participants

This study was conducted at the Royal London Hospital a MTC situated in East London, United Kingdom. This is the tertiary referral center for adult patients with spinal trauma in the North East London Trauma Network. All cases are entered onto a

prospectively maintained database and this database was searched for adult patients (18 years or older) who underwent emergency instrumented spinal surgery for trauma, tumor, infection, or any condition with deteriorating neurology. Patients were categorized according to COVID-19 status. This study included 19 patients, comprising 11 patients negative for COVID-19 and 8 patients positive for COVID-19 (Table 1). If a patient had a positive COVID-19 swab at the time of surgery, or classical symptom (cough or fever) with positive chest radiography or computed tomography (CT) scan showing characteristic COVID-19 changes,<sup>10</sup> they were entered into the COVID-19-positive group. Exclusion criteria were emergency spinal surgery without instrumentation of  $\geq 2$  vertebral levels; patients admitted requiring emergency spinal surgery but transferred to an external hospital for surgery to create hospital capacity at the MTC; and patients with COVID-19 symptoms but without confirmatory swab, chest radiography, or CT finding. Hospital governance board considered this a service evaluation. We excluded 15 patients negative for COVID-19 who underwent spinal instrumentation for trauma during this time, as they were stable patients who were transferred out to a local non-NHS hospital to create capacity in the MTC. Nine other U.K. specialist spinal centers were contacted to contribute patients to the study, but no spinal operations had been performed on patients with the above inclusion criteria during this time.

### Patients

Patients were classified as COVID-19 positive in the following circumstances: a positive throat-and nose-swab assay using reverse transcriptase-polymerase chain reaction (RT-PCR) for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) obtained before surgery; patient with symptoms of cough and/or fever and chest radiography and/or CT finding showing COVID-19 changes.<sup>9</sup> Patients were classified as COVID-19 negative if they were asymptomatic with negative throat-and nose-swabs assays using RT-PCR for SARS-CoV-2. Repeat swabs were performed for patients with suspicious clinical symptoms and negative initial swab results.

### Variables and Data Sources

For each patient, the following data were collected: baseline demographics including age, sex, and body mass index (BMI), medical comorbidities, smoking status, presence of preoperative COVID-19 symptoms, presence of preoperative temperature  $>37.5^{\circ}\text{C}$ , preoperative oxygen saturations, preoperative requirement for oxygen therapy, RT-PCR SARS-CoV-2 swab results, chest radiography and CT findings, American Society of Anesthesiologists grade, operation location (cervical or thoracolumbar), time between admission and surgery, indication for instrumented spinal surgery and preoperative American Spinal Injury Association impairment scale grade. The decision to perform surgery and type of surgery performed (anterior vs. posterior decompression/number of stabilized levels) was based on the judgment of the consultant spinal surgeon. Timing of surgery also was dependent on the judgment of the treating surgeon and reflected requirement to treat associated injuries, need for further investigations and most crucially, theater availability during a time of limited availability. The primary outcome was presence of postoperative mortality and/or complications within the first 30 days. Secondary

**Table 1.** Baseline Demographics and Injury Characteristics for COVID-19–Positive and COVID-19–Negative Patient Groups

Characteristic	COVID-19–Positive Group (n = 8)	COVID-19–Negative Group (n = 11)	P Value
Age, average years (range)	41.75 (19–65)	46.36 (21–79)	0.62*
Sex, n (%)			1.00†
Female	1 (12.5%)	2 (18%)	
Male	7 (87.5%)	9 (82%)	
Injury site, n (%)			1.00†
Cervical	2 (25%)	4 (36%)	
Thoracolumbar	6 (75%)	7 (64%)	
BMI, kg/m <sup>2</sup> , n (%)			1.00†
Normal (20–24.9)	4 (50%)	5 (45.5%)	
Abnormal (<20 or >24.9)	4 (50%)	6 (54.5%)	
ASA grade, n (%)			0.85‡
I	4 (50%)	7 (64%)	
II	3 (37.5%)	2 (18%)	
III	1 (12.5%)	2 (18%)	
IV	0 (0%)	0 (0%)	
Time from admission to surgery, average days (range)	5.50 (1–14)	3.18 (1–7)	0.25*
Indication for surgery			1.00†
Trauma	7 (87.5%)	9 (81.9%)	
Other	1 (12.5%)	2 (18.1%)	
Other:			
Infection	1 (12.5%)	1 (9%)	
Degenerative	0 (0%)	1 (9%)	
Neoplasia	0 (0%)	0 (0%)	
Preoperative AIS			0.08‡
A	0 (0%)	3 (12.5%)	
B	0 (0%)	0 (0%)	
C	1 (12.5%)	3 (25%)	
D	4 (50%)	3 (12.5%)	
E	3 (37.5%)	2 (18%)	

COVID-19, coronavirus disease 2019; BMI, body mass index; ASA, American Society of Anesthesiologists; AIS, American Spinal Injury Impairment Scale.

\*Independent (unpaired) *t* test.

†Fisher's exact test.

‡Mann-Whitney *U* test.

outcomes were length of postoperative stay and requirement for ICU admission.

### Statistical Analysis

Statistical analysis was conducted using SPSS statistics software, version 25 (IBM Corp., Armonk, New York, USA). A *P*-value < 0.05 was considered significant. Categorical variables were compared using the Fisher exact test. Continuous variables were compared

using unpaired *t* test for normally distributed data, and Mann–Whitney *U* test for data not normally distributed. BMI status, smoking status, surgical indication, and presence of medical comorbidities were converted to categorical binomial variables. COVID-19–positive and COVID-19–negative groups were compared for baseline demographics and characteristics. The Fisher exact test was used to compare baseline sex, BMI status, smoking status, injury site, surgical indication, medical

**Table 2.** Health Status and Physiology Variables for COVID-19–Positive and COVID-19–Negative Patient Groups

Variable	COVID-19–Positive Group (n = 8)	COVID-19–Negative Group (n = 11)	P Value
Preoperative temperature >37.5°C, n (%)			0.11*
Pyrexial	4 (50%)	1 (9%)	
Apyrexial	4 (50%)	10 (91%)	
Preoperative oxygen saturations, n (%)			1.00*
≥95%	4 (50%)	5 (45%)	
<95%	4 (50%)	6 (55%)	
Preoperative oxygen administration, n (%)			1.00*
Administered	4 (50%)	6 (55%)	
Not administered	4 (50%)	5 (45%)	
Smoking status, n (%)			1.00*
Smoker	4 (50%)	6 (55%)	
Nonsmoker	4 (50%)	5 (45%)	
Medical comorbidities, n (%)			1.00*
Yes	3 (37.5%)	4 (36.4%)	
No	5 (62.5%)	7 (63.6%)	
Number of comorbidities			
0	5 (62.5%)	7 (64%)	
1	3 (37.5%)	1 (9%)	
2	0 (0%)	1 (9%)	
3	0 (0%)	0 (0%)	
>3	0 (0%)	2 (18%)	

COVID-19, coronavirus disease 2019.  
\*Fisher exact test.

co-morbidities, preoperative oxygen requirement, preoperative temperature (fever) and preoperative oxygen saturation. Mann–Whitney U test was used to compare preoperative American Spinal Injury Impairment Scale score and American Society of Anesthesiologists grade. The independent samples t test was used to compare age and time from admission to surgery.

Postoperative outcomes for the 2 groups were compared using the Fisher exact test for occurrence of complications and ICU admission, and independent samples t test for time from surgery to hospital discharge. Postoperative outcomes were correlated to preoperative baseline characteristics in the COVID-19–positive group. Specifically occurrence of complications and requirement for ICU admission were correlated to presence of preoperative temperature (fever), preoperative oxygen saturation, comorbidities, BMI status, and smoking status. Bivariate correlation test was performed.

## RESULTS

### Patients

Patients in both treatment groups had comparable baseline characteristics (Tables 1 and 2). In the COVID-19–positive group,

5 patients had been diagnosed by positive nasopharyngeal swab and 3 by presence of symptoms with characteristic chest radiography or CT. The average time between admission and surgery in the COVID-19–positive and –negative groups was 5.5 and 3 days, respectively ( $P = 0.25$ ).

### Primary Outcomes: Mortality and Complications

There were no mortalities in either treatment group. Four COVID-19–positive patients (50%) developed a complication, compared with 6 (55%) in the COVID-19–negative group ( $P > 0.05$ ) (Table 3). The commonest complication in both groups was respiratory infection. In the COVID-19–positive group, smoking, abnormal BMI, preoperative oxygen requirement, presence of fever, preoperative oxygen saturations <95% and presence of comorbidities correlated with increased risk of complications.

### Secondary Outcomes: ICU Admission and Length of Postoperative Stay

Three COVID-19–positive patients (37.5%) required ICU admission, compared with 4 (36%) in the COVID-19–negative group ( $P > 0.05$ ). In the COVID-19–positive group, smoking, abnormal

**Table 3.** Postoperative Outcomes for COVID-19–Positive and COVID-19–Negative Patient Groups

	COVID-19–Positive Group (n = 8)	COVID-19–Negative Group (n = 11)	P Value
Mortality, n (%)	0 (0%)	0 (0%)	1.00*
Postoperative complications, n (%)			1.00*
Yes	4 (50%)	6 (55%)	
No	4 (50%)	5 (45%)	
Categories†			
Respiratory infection	2 (25%)	3 (27%)	
Acute Kidney Injury	1 (12.5%)	1 (9%)	
Septic shock	1 (12.5%)	1 (9%)	
Myocardial Infarction	0 (0%)	0 (0%)	
Thromboembolic disease	0 (0%)	0 (0%)	
Acute respiratory distress syndrome	0 (0%)	0 (0%)	
Multiorgan dysfunction	0 (0%)	0 (0%)	
Severe metabolic acidosis	1 (12.5%)	2 (18%)	
Coagulation dysfunction	0 (0%)	0 (0%)	
Neurologic injury	0 (0%)	1 (9%)	
Metalwork failure	1 (12.5%)	0 (0%)	
Wound infection	1 (12.5%)	0 (0%)	
Reoperation	1 (12.5%)	1 (9%)	
Requirement for ICU admission, n (%)			1.00*
Admitted	3 (37.5%)	4 (36%)	
Not admitted	5 (62.5%)	7 (64%)	
Time from surgery to hospital discharge, average days (range)	19.25 (4–30)	10.36 (4–20)	0.02‡

COVID-19, coronavirus disease 2019; ICU, intensive care unit.  
 \*Fisher exact test.  
 †Some patients developed more than one complication.  
 ‡Independent (unpaired) *t* test.

BMI, preoperative oxygen requirement, presence of fever, and preoperative oxygen saturations <95% correlated with increased risk of ICU admission. The average time between surgery and hospital discharge in the COVID-19–positive and –negative groups was 19 and 10 days, respectively ( $P = 0.02$ ).

## DISCUSSION

This is the first study describing the outcomes of instrumented spinal surgery during the COVID-19 pandemic. We have shown there was no difference in the occurrence of mortality, complications, or ICU admission between COVID-19–positive and COVID-19–negative patients. Length of stay was greater in the COVID-19–positive group. We found risk factors associated with increased risk of complications for COVID-19–positive patients were smoking, abnormal BMI, preoperative oxygen requirement, presence of fever, and preoperative oxygen saturations <95%.

London was the epicenter for the U.K. outbreak. The Royal London Hospital is the United Kingdom's busiest MTC and a COVID-19 specialist hub. Tower Hamlets, our local borough, was the epicenter of the London outbreak, making our geographic location ideal to investigate the effect of COVID-19 in emergency instrumented spinal surgery. Emergency spinal procedures performed in this study followed international consensus guidance on recommended indications for surgery.<sup>6</sup> We had relatively few patients in the COVID-19–negative group. The reason for this was that patients who required emergency spinal instrumentation and were deemed clinically stable were transferred out of the MTC to a local hospital that only admitted patients negative for COVID-19. This was done to ensure capacity was created and maintained in the MTC. Patients in this study therefore represented a sample of the most severely affected hospitalized patients, mostly polytrauma, and explain why complication rates were comparatively high in the literature.<sup>7–9</sup>

In the early weeks of the UK outbreak, there was a shortage of testing kits. We therefore included patients in the COVID-19–positive group who either had a positive swab before surgery, or had a classical symptom (fever or cough), no other source of infection, and chest radiography and/or CT showing characteristic features.<sup>11</sup> The definitive test for SARS-CoV-2 is the real-time RT-PCR test; however, sensitivity is low. A study of 205 patients with positive RT-PCR assays for serum SARS-CoV-2 found sensitivity of RT-PCR for viral RNA was 93% with bronchoalveolar lavage, 72% with sputum, 63% with nasal swabs, and 32% with throat swabs.<sup>12</sup> The sensitivity of RT-PCR assays in polytrauma and surgical patients remains unknown and is thought to be lower. Sensitivity for various diagnostic methods varies with disease stage and degree of viral multiplication.<sup>13</sup> False negatives are a real clinical problem with RT-PCR SARS-CoV-2 swabs, and several negative tests might be required in a single case to be confident about excluding the disease. For hospitalized patients, radiographic confirmation has a greater sensitivity.

CT of the chest is a sensitive diagnostic method for detection of SARS-CoV-2. In a series of 51 patients with chest CT and RT-PCR assay performed within 3 days, the sensitivity of CT for COVID-19 infection was 98% compared with RT-PCR sensitivity of 71% ( $P < 0.001$ ).<sup>13</sup> Similarly, chest radiography for hospitalized patients is a sensitive diagnostic tool. In patients with COVID-19 requiring hospitalization, 69% had an abnormal chest radiograph at the initial time of admission, and 80% had radiographic abnormalities during hospitalization.<sup>14</sup> There is no perfect diagnostic test for COVID-19 that has both high sensitivity and high specificity. In the early months of the pandemic, when many countries were short of testing equipment, symptoms and radiological confirmation were used as the recommended basis for clinical diagnosis.<sup>15</sup>

Many studies have demonstrated high mortality rates for patients with COVID-19 undergoing emergency surgical procedures, as high as 20%–30%.<sup>5</sup> This has made many surgeons apprehensive about operating on patients with COVID-19. We contacted 9 other U.K. specialist spinal centers to contribute patients to the study, but no operations had been performed on patients with COVID-19 with the aforementioned inclusion criteria, largely due to concerns about increased perioperative mortality and morbidity. This demonstrates the uniqueness and rarity of this patient cohort.

We had no mortalities in either of our surgical groups at 30 days. Safety is a founding paradigm of surgery, and so understanding risk is important for future departmental planning should a second wave of the pandemic occur.<sup>16</sup> Our results suggest that for life- or limb-threatening emergency procedures, emergency spinal surgery can be undertaken without a substantial increase in mortality under certain conditions. We still advocate that all patients should be consented for the possibility of catching COVID-19, disease progression, ICU admission, and death. Patients at particular risk for adverse perioperative outcomes are those with an abnormal BMI, smokers, patients requiring preoperative oxygen, and those with preoperative fever ( $>37.5^{\circ}\text{C}$ ) and oxygen saturations  $<95\%$ .

The commonest complication we encountered was respiratory infection. Zhou et al.<sup>17</sup> reported on 191 patients with COVID-19 in the ICU and showed that respiratory failure

(54%) was the commonest complication. Cardiorespiratory and renal complications are common in patients with COVID-19 due to the high numbers of angiotensin-converting enzyme-2 receptors within the alveoli epithelial cells, myocardium and kidney.<sup>18</sup> The COVID-19 protein envelope has a high affinity to these membranous receptors, enabling the virus to enter host cells and replicate. Smoking upregulates angiotensin-converting enzyme-2 receptors. This is one of many mechanisms through which smoking is thought to adversely affect clinical outcomes.

Our current approach to management of patients with COVID-19 requiring emergency spinal surgery is to assess each patient on an individual basis, balancing risks of respiratory compromise from COVID-19, with risks of not operating which may be greater. We liaise closely with our intensivists for this purpose to make a multidisciplinary decision.

### Limitations

This is a retrospective observational study with low patient numbers. This is expected, given the emergency context of the pandemic, short time frame and complexity of surgery involved, however this makes our study vulnerable to bias, confounding and type 2 statistical error. Accordingly, our results should be interpreted with caution. We did not perform a power analysis as we had wanted to include as many patients in the short time frame as possible. Many published clinical studies on COVID-19 include a wide heterogeneity of included patients. In our study, patients represented a select cohort of the most severely affected hospitalized spinal patients requiring instrumented surgery. To mitigate differences between groups, we excluded patients deemed more stable who could be transferred out to a neighboring private hospital. This introduced sample bias. We found baseline characteristics between groups were similar; one explanation for this is type 2 statistical error. Our sample was too small for multivariate analyses; therefore the results were confounded. Randomized trials are not ethical or practical, and despite inherent weaknesses, we believe our study provides an important and timely insight into perioperative outcomes for patients with COVID-19 who undergo emergency instrumented spinal surgery. We advocate multicenter trials and meta-analyses using collaborative data for future studies on this rare patient cohort.

### CONCLUSIONS

Emergency instrumented spinal surgery in patients positive for COVID-19 was associated with increased length of hospital stay. There was no difference in occurrence of complications or ICU admission. Risk factors for increased morbidity in patients with COVID-19 included smoking, abnormal BMI, preoperative oxygen requirement, fever and saturations  $<95\%$ . Under certain conditions, our results suggest that for life- or limb-threatening emergency procedures, emergency spinal surgery can be undertaken without a substantial increase in perioperative mortality or morbidity.

### CRedit AUTHORSHIP CONTRIBUTION STATEMENT

**Mathew Sewell:** Data curation, Formal analysis, Writing - original draft. **Fahid Rasul:** Data curation, Formal analysis, Writing - original

draft. **Kathak Vachhani:** Formal analysis. **Fady Sedra:** Conceptualization, Methodology, Supervision, Writing - review & editing. **Syed Aftab:** Conceptualization, Methodology, Validation, Supervision. **Suresh Pushpanathan:** Conceptualization, Supervision, Validation.

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## REFERENCES

- 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.
2020. Listing of WHO's response to COVID-19. Available at: <https://www.who.int/news/item/29-06-2020-covidtimeline>. Accessed June 29, 2020.
- NHS. New nightingale hospital to fight coronavirus. 2020. Available at: [www.england.nhs.uk/2020/03/new-nightingale-hospital-to-fight-coronavirus/](http://www.england.nhs.uk/2020/03/new-nightingale-hospital-to-fight-coronavirus/). Accessed March 24, 2020.
- Lei S, Jiang F, Su W, et al. Clinical characteristics and outcomes of patients undergoing surgeries during the incubation period of COVID-19 infection. *EClinicalMedicine*. 2020;21:100331.
- Kayani B, Onochie E, Patil V, et al. The effects of COVID-19 on perioperative morbidity and mortality in patients with hip fractures. *Bone Joint J*. 2020;1-10.
- Ghogawala Z, Kurpad S, Falavigna A, et al. Editorial. COVID-19 and spinal surgery. *J Neurosurg Spine*. 2020;17:1-3.
- Fehlings MG, Vaccaro A, Wilson JR, et al. Early versus delayed decompression for traumatic cervical spinal cord injury: results of the Surgical Timing in Acute Spinal Cord Injury Study (STASCIS). *PLoS One*. 2012;7:e32037.
- Furlan JC, Noonan V, Cadotte DW, Fehlings MG. Timing of decompressive surgery of spinal cord after traumatic spinal cord injury: an evidence-based examination of pre-clinical and clinical studies. *J Neurotrauma*. 2011;28:1371-1399.
- Sewell MD, Vachhani K, Alrawi A, Williams R. Results of early and late surgical decompression and stabilization for acute traumatic cervical spinal cord injury in patients with concomitant chest injuries. *World Neurosurg*. 2018;118:e161-e165.
- Chaudhary SB, Hullinger H, Vives MJ. Management of acute spinal fractures in ankylosing spondylitis. *ISRN Rheumatol*. 2011;2011:150484.
- Kanne JP, Little BP, Chung JH, Elicker BM, Ketaj LH. Essentials for radiologists on COVID-19: an update-radiology scientific expert panel. *Radiology*. 2020;200527.
- Wang W, Xu Y, Gao R, et al. Detection of SARS-CoV-2 in different types of clinical specimens. *JAMA*. 2020;323:1843-1844.
- Fang Y, Zhang H, Xie J, et al. Sensitivity of chest CT for COVID-19: comparison to RT-PCR. *Radiology*. 2020;296:E115-E117.
- Wong HYF, Lam HYS, Fong AH, et al. Frequency and distribution of chest radiographic findings in COVID-19 positive patients. *Radiology*. 2019;201160.
- BMJ Best Practice. Coronavirus disease 2019 (COVID-19). 2020. Available at: <https://bestpractice.bmj.com/topics/en-gb/3000168>. Accessed June 10, 2021.
- Giorgi PD, Villa F, Gallazzi E, et al. The management of emergency spinal surgery during the COVID-19 pandemic in Italy. *Bone Joint J*. 2020;102-b:671-676.
- Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet*. 2020;395:1054-1062.
- Phua J, Weng L, Ling L, et al. Intensive care management of coronavirus disease 2019 (COVID-19): challenges and recommendations. *Lancet Respir Med*. 2020;8:506-617.

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