Title
Scoring System to Triage Patients for Spine Surgery in the Setting of Limited Resources: Application to the Coronavirus Disease 2019 (COVID-19) Pandemic and Beyond

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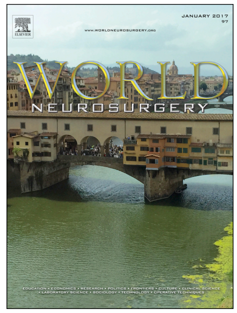

Scoring system to triage patients for spine surgery in the setting of limited resources: Application to the COVID-19 pandemic and beyond

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Title: Scoring system to triage patients for spine surgery in the setting of limited resources: Application to the COVID-19 pandemic and beyond

Short Title: Spine Urgency Score

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Abstract

Background

As of May 04, 2020, the COVID-19 pandemic has affected over 3.5 million people and touched every inhabited continent. Accordingly, it has stressed health systems the world over leading to the cancellation of elective surgical cases and discussions regarding healthcare resource rationing. It is expected that rationing of surgical resources will continue even after the pandemic peak, and may recur with future pandemics, creating a need for a means of triaging emergent and elective spine surgery patients.

Methods

Using a modified Delphi technique, a cohort of 16 fellowship-trained spine surgeons from 10 academic medical centers constructed a scoring system for the triage and prioritization of emergent and elective spine surgeries. Three separate rounds of videoconferencing and written correspondence were used to reach a final scoring system. Sixteen test cases were used to optimize the scoring system so that it could categorize cases as requiring emergent, urgent, high-priority elective, or low-priority elective scheduling.

Results

The devised scoring system included 8 independent components: neurological status, underlying spine stability, presentation of a high-risk post-operative complication, patient medical comorbidities, expected hospital course, expected discharge disposition, facility resource limitations, and local disease burden. The resultant calculator was deployed as a freely-available web-based calculator (https://jhuspine3.shinyapps.io/SpineUrgencyCalculator/).

Conclusion

Here we present the first quantitative urgency scoring system for the triage and prioritizing of spine surgery cases in resource-limited settings. We believe that our scoring system, while not all-encompassing, has potential value as a guide for triaging spine surgical cases during the COVID pandemic and post-COVID period.

Key Words: COVID-19; resource allocation; medical ethics; triage; spine surgery; pandemic; rationing; triage

Background

On December 27, 2019 the first case of the novel Coronavirus, COVID-19 (SARS-CoV-2) was reported in Wuhan, China as the cause of a new viral pneumonia with the potential to culminate in acute respiratory distress syndrome (ARDS) and/or death.[1,2] Since that time it has spread rapidly to affect nearly every country, placing significant stresses on the global healthcare system.[3] In order to mobilize resources to combat this pandemic, the Centers for Medicare and Medicaid Services (CMS),[4] the Centers for Disease Control and Prevention (CDC),[5] and multiple professional organizations[6,7] recommended the cancellation of elective surgical procedures. In spite of this, it was recognized that there were cases, many of them neurosurgical, which required urgent or emergent intervention to minimize patient morbidity and maximize the chances of an optimal outcome.[8] In response, several centers have presented frameworks for the management of neurosurgical patients presenting during the COVID-19 pandemic.[8–11] Additionally, a triage scoring system has been previously developed in an attempt to guide spine surgery consults.[12,13] However, to date, there has not been a systematic, multi-institutional scoring system that includes resource availability and disease burden to aid in triaging spine surgery patients during this crisis. Though certain symptoms referable to chronic spinal conditions may not necessarily be life threatening, these can cause significant pain and disability prompting the challenge of determining who and when to operate in times of crises.

It is recognized that effective triaging of these cases in the post-COVID era will be essential to prevent the healthcare system from being overwhelmed by the backlog of elective spinal cases that have been deferred because of the COVID-19 pandemic.[14–16] Recently, a scoring system aimed at triaging such cases has been published in the general surgery literature,[17] however no comparable system has been described for spine patients. Here we present an applicable example of such a system assembled based upon input by a multi-institutional collaboration. This scoring system is designed to assist in two ways. First, it may assist spine surgeons and administrators with triaging surgical patients during the COVID-19 pandemic. Second, the scoring system may help health systems triage elective cases in the post-COVID crisis, which is likely to also see a relative shortage of surgical resources and has been described by some as a potential collateral pandemic.[15]

Methods

Scoring System Development

To generate this scoring system, the first author proposed an *a priori* scale highlighting those elements thought to be pertinent to the triaging of an operative spine patient in the setting of limited resources. The elements applicable to the spine patient included the patient's current neurological status (rapidity of progressive, severity), the presence of underlying spinal instability, and radiographic evidence of neural element compression. Several general elements were added that could be used to triage any surgical patient, including general patient health/comorbidities, expected resource utilization, current resource availability, and local disease burden. Medical comorbidities were pulled from the Charlson Comorbidity Index[18] and from previously published series describing comorbidities associated with increased symptom severity in patients infected with the SARS-CoV-2 virus.[2,19–23] After identifying these elements, weights were initially assigned based on input from surgeons at the lead institution using a modified Delphi approach that included both neurosurgical and orthopaedic spine surgeons. Component weighting of the preliminary scale was tested using ten example spine patients, testing the assessed urgency of the patient as determined by the scoring system against the consensus opinion of the group of surgeons.

After identifying a preliminary scoring system, a multi-institutional group was convened, including neurosurgical and orthopaedic spine surgeons from multiple institutions with varying levels of experience. A modified Delphi approach was again used to alter the weights assigned to the categories to refine the preliminary score. Three rounds of written communication, polling, and electronic teleconferencing sessions were used to solicit input. Example cases were again devised to test the degree of agreement between the scoring system and the consensus opinions regarding the urgency of the hypothetical patient's issue (Supplemental Data). The final scoring system was then deployed as a freely available, web-based calculator (Figure 1; https://jhuspine3.shinyapps.io/SpineUrgencyCalculator/).

Details of the multi-institutional panel

The study group was comprised of 16 spine surgeons representing 12 institutions in 11 municipalities distributed over the Northeast, Mid-Atlantic, Midwest, South, and West Coast regions, including New York, Baltimore, Boston, Chicago, and San Francisco. All surgeons were fellowship trained and a mean of 12.8±9.3 years out of residency. Eleven surgeons were neurosurgeons and 5 were orthopaedic surgeons.

Results

Our modified Delphi approach demonstrated overall agreement with the scoring system in example cases to be 66.3% and 71.5% in the first and last survey rounds, respectively, resulting in the scoring system shown in **Table 1**. The score is composed of 8 domains: neurological status, spinal stability, presentation of a high-risk post-operative complication, medical comorbidities, predicted hospital course, post-discharge placement, resource availability concerns, and local disease burden. Within neurological status, patients are categorized by their deficit progression, the presence of a radiographic correlate to their neurological symptoms, and the degree of impairment that their deficit causes in ambulation or the ability to perform activities of daily living (ADL).

The scoring system runs from -19 (lowest priority elective case) to 91 (highest priority emergent case) and classifies cases as "emergent," "urgent," "high-priority elective," or "low-priority elective" as identified in **Table 2**. Additionally, in **Table 2** we surgical timeframes for each category. However, these timeframes are meant as suggestions and should be no means replace an individual surgeon's clinical judgement.

Within the scoring system, higher points are assigned to patients with more pressing surgical needs, including more severe neurological deficits, underlying spinal instability, and the presence of a high-risk post-operative complication. Patients with more extensive comorbidities, longer expected hospitalizations, and a need for post-discharge placement to an inpatient rehabilitation facility or skilled nursing facility are assigned lower points because they are believed to be at highest risk for adverse outcomes when hospitalized during the current pandemic. Additionally, points are subtracted for patients being treated at facilities in regions with high disease burden and those with shortages of intensive care unit (ICU) beds or personal protective equipment

(PPE). We found that this scoring system was able to predict the optimal surgical timing identified by >70% of the surgeon cohort for each of the sample cases.

Discussion

Since the peak of the COVID-19 pandemic, there has been immense pressure placed upon healthcare systems worldwide. Various resources, including personal protective equipment (PPE), ventilators, intensive care unit (ICU) beds, and medical staff had been significantly limited and stretched thin.[9,17,24,25] In many cases, resources had been stretched so thin that health systems were required to consider how best to allocate their limited resources.[3] To address this, many hospital systems have curtailed non-urgent surgical procedures, allowing crucial resources to be redeployed for the treatment of COVID-19 patients.[11,15] Nevertheless, some spinal pathologies require urgent or emergent intervention (e.g. cauda equina syndrome) to prevent severe adverse patient outcomes (e.g. death, permanent disability).[15] Though prior publications have highlighted which surgical patients qualify for urgent or emergent interventions,[8,10,12,13] they have not provided an algorithm for the prioritization of such cases in the setting of potential resource shortages. Here we present a scoring system devised by a multi-institutional collaboration that aims to assist with these triage issues. The ability to assist with both populations is a strength of this scoring system, which we feel may be a useful tool for health systems both during the COVID pandemic and in the post-crisis period, as they struggle to accommodate the large volume of non-emergent surgical cases. Additionally, though we hope such a need does not arise, the present scoring system could also have value in the triaging of patients if a "second wave" of the coronavirus pandemic occurs, which may lead to further resource limitations.[26] Such a wave occurred during the 1918 Spanish influenza pandemic[27] and many experts have speculated that a similar phenomenon could occur during the present pandemic.[26,28] Furthermore, the framework of the proposed scoring system could apply to future pandemics where healthcare resources are similarly stretched as the current COVID-19 pandemic.

Prior examinations of triaging in neurosurgery

There have been several broad descriptions of triage strategies presented in the neurosurgical literature,[29,30] and guidelines from the American College of Surgeons (ACS) currently divide surgeries into five levels based upon apparent acuity.[11] However a large proportion of spinal cases require emergent or urgent addressal[29] and fall within the same category of the ACS system. Consequently, it is not clear that such a system possesses the granularity necessary to triage patients with surgical issues of grossly similar acuity. Similar limitations are noted for other published triaging systems from the trauma surgery literature[29,31] and for the prior schema in the neurosurgical and orthopedic literature.[29,30]

In addition to a perceived lack of granularity, neurosurgical triage systems published in the pre-COVID era have predominately focused on emergent surgical issues. Triage amongst non-emergent cases has been largely overlooked. One exception to this is the "Accountability for Reasonableness (A4R)" framework described by Ibrahim and colleagues[32] to emphasize scheduling fairness and minimize operating room downtime at an academic center seeing a mixture of emergent and elective cases. Unlike the present scoring system however, their framework was purely qualitative – triaging was performed by a single stakeholder without an obvious means by which surgical cases were ranked. Another exception is the Calgary Spine

Severity Score proposed by Lwu et al.[12] that assessed spine referrals based on the clinical, pathological, and radiological aspects. Similar to the A4R framework, however, this score was not intended for implementation in the setting of a crisis or the acute resource shortages that are expected in the post-COVID era.[15,16]

Identifying surgical priority in the setting of COVID

Several institutions have reported their experiences with triaging neurosurgical patients during the COVID-19 pandemic.[8,10] Burke et al,[8] described a multilevel algorithm devised by a multidisciplinary team using a modified Delphi system. Their system included three tiers: case urgency, operating room availability, and post-operative bed availability. Assuming adequate surgical resources were available, patients with emergent surgical issues (e.g. epidural hematoma) were prioritized for operative management regardless of local disease burden. Urgent cases were scheduled if sufficient resources were available and local disease burden was low enough to be managed without assistance from outside institutions. Lastly, elective cases were to be deferred unless local disease burden was negligible. Similar to the present system, certain indications were flagged as emergent surgical issues e.g. intracranial hemorrhage, shunt obstruction, cauda equina syndrome. However, the authors only generally identified what constituted an urgent case, namely a surgical issue requiring treatment within 2 weeks that was not identified in the emergency list. Elective cases were similarly identified as all cases that did not fall into the above two categories. Unlike the system presented here, however, no formalized system was identified for the prioritization of cases within the urgent or elective categories.

Eichberg et al[10] similarly recommended that non-urgent cases be deferred. They additionally suggested that surgeons consider alterations to their surgical practice (e.g. the use of dissolvable suture) to decrease the likelihood that patients would have to return for in-person follow-up, which would increase their COVID-19 exposure risk. Categorizations of surgical emergencies similar to those of Burke et al[8] and Eichberg et al[10] have also been reached by groups at Harvard[11] and abroad.[9,25] Additionally, a joint publication by the American Association of Neurological Surgeons (AANS), Congress of Neurological Surgeons (CNS), and Society for Neuro-Oncology (SNO) made recommendations to prioritize adjuvant therapies (e.g. chemotherapy and radiotherapy) over earlier surgical intervention for spinal and intracranial malignancies, as this will decrease the risks posed by hospitalizing oncologic patients in the same facility as COVID-19-positive patients.[33] However, the groups acknowledge that this is not always possible, and that care deferral may cause some elective cases to progress to the point of requiring urgent operative management. The European Association for Neurosurgical Societies has attempted to address the question of how to prioritize elective neurosurgical cases through an “Adapted Elective Surgery Acuity Scale.” Unfortunately, while this scale provides some guidance, the three tiers it employs are quite broad and there are no guidelines for prioritizing cases within a category or a given diagnosis (e.g. “degenerative spinal pathology”).[34] Consequently, we feel the need for a means of triaging both emergent and elective spine cases remains unmet.

While there have been several general frameworks highlighting those cranial pathologies requiring emergent management,[8,10,11] there has only been one description of a framework for triaging emergent spine surgeries.[25] Derived from the experiences at a single Italian center tasked with treating cord compression and spinal instability, the framework of Giorgi and colleagues is a care pathway intended to expedite the identification, treatment, and safe discharge of patients with spine emergencies. Priority within the system was based upon American Spinal Injury Association (ASIA) grade and radiographic evidence of instability. Though good results were described for the 19 patients treated under the framework, the pathway is non-quantitative and seemingly lacks the granularity to prioritize between two or more emergent patients. Similarly, it is not equipped to triage non-emergent cases.

A more quantitative approach was described by Jean and colleagues[35] based upon nearly 500 respondents to an internet survey, asking respondents to assign an urgency score to each of nine hypothetical cases. The authors found mild-to-moderate agreement regarding the extent of surgical urgency for each case (range 22.8-37.0%), however, their "acuity index" was simplistic in that it was based solely upon the perceived case risk and case urgency assigned to it by respondents. Case risk was graded on a 1 to 4 scale ("no risk" and "cannot postpone") and case urgency on a 1 to 5 scale ("leave until after the end of the pandemic" and "case already done"). The scale itself did not incorporate neurological status, patient comorbidities, or local resource limitations, all of which are likely to influence the timing of operative management. Because of this lack of granularity, it is unclear that this "acuity index" can be generalized to other case scenarios, thus limiting its potential utility relative to the multidimensional scoring system described here.

Limitations

As with scoring systems published in other domains of neurosurgery, the present scoring system is not intended to be prescriptive in its guidance. Rather, we present it as a potential tool to aid surgeons and healthcare systems when triaging patients in times of national crisis or global resource shortages. As with the triage frameworks presented to date, the present scoring system is derived from expert opinions. Consequently, the scoring system is limited by the biases of the surgeons recruited and their respective institutions. We attempted to address this by recruiting surgeons at multiple levels of training, at academic centers spread across a large geographic region subjected to varying COVID-19 burdens. Furthermore, by only including surgeons into the decision-making process of the urgency of spine patients, there is potential that additional points from the non-surgical and administrative personnel could have altered the final scoring system. Additionally, in an effort to maximize the usability of the scoring system, it was necessarily simplified and is consequently not all encompassing. For example, the broad term of "new neurologic deficit" was included under the "High-Risk Postoperative Complication" category, however, this leaves it up to the treating surgeon whether this new deficit is "high-risk". Therefore, while it can assist in determining surgical priority, final disposition should be based upon the clinical judgment of the treating surgeon and institution. Nevertheless, we believe that it can be an effective tool for informing clinical stakeholders as to how each patient's case may be triaged at peer institutions. Our scoring system is also limited by the fact that it operates on the assumption that the patient desires surgery at the same time recommended by the treating surgeon. This is not always the case and the ultimate timing of surgery must therefore rely on an in-depth discussion between provider and patient. Finally, the present scoring system was devised with the COVID-19 pandemic in mind. Consequently, it could be argued that it may not be applicable to other resource challenging situations, and future pandemics may limit resources in a manner not assessed in the current work. However, we feel that the modular structure employed could easily be adapted to other crises that cause a shortage of medical resources. Therefore, the present system may have utility beyond the present crisis and any “second wave” that may arise.

Conclusion

Here we present a scoring system for the triaging of spine surgery patients during times of crisis and severe resource scarcity. Our system was developed by a multi-institutional panel using a modified Delphi technique and has the potential to assist surgeons, hospital administrators, and other clinical stakeholders in assigning priority to both emergent and non-emergent spine surgery patients. While not intended to be prescriptive, this scoring system may prove useful as a guide during both the COVID crisis and the post-COVID period to help prioritize patients with the greatest surgical needs, though determining the urgency of an individual procedure should be left to the operating surgeon. Additionally, we believe the modular structure of the scoring system implies that it may potentially be adapted to other crises resulting in an acute shortage of medical resources.

References

1. Zhu N, Zhang D, Wang W, et al. A Novel Coronavirus from Patients with Pneumonia in China, 2019. *N Engl J Med*. 2020;382(8):727-733. doi:10.1056/NEJMoa2001017
2. Guan W, Ni Z, Hu Y, et al. Clinical Characteristics of Coronavirus Disease 2019 in China. *N Engl J Med*. Published online February 28, 2020:NEJMoa2002032. doi:10.1056/NEJMoa2002032
3. Emanuel EJ, Persad G, Upshur R, et al. Fair Allocation of Scarce Medical Resources in the Time of Covid-19. *N Engl J Med*. Published online March 23, 2020:NEJMsb2005114. doi:10.1056/NEJMsb2005114
4. Centers for Medicare & Medicaid Services. Non-Emergent, Elective Medical Services, and Treatment Recommendations. Published 2020. Accessed April 7, 2020. https://www.cms.gov/files/document/31820-cms-adult-elective-surgery-and-procedures-recommendations.pdf
5. Centers for Disease Control and Prevention (CDC). Coronavirus Disease 2019 (COVID-19): Healthcare Facility Guidance. Published 2020. Accessed April 7, 2020. https://www.cdc.gov/coronavirus/2019-ncov/hcp/guidance-hcf.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fhealthcare-facilities%2Fguidance-hcf.html
6. Surgeons AC of. COVID-19: Recommendations for Management of Elective Surgical Procedures. ACS: COVID-19 and Surgery. Published 2020. Accessed April 7, 2020. https://www.facs.org/covid-19/clinical-guidance/elective-surgery
7. Bono CM, Dohring EJ, Finkenberg JG, et al. NASS Guidance Document on Elective, Emergent, and Urgent Procedures. Published 2020. Accessed April 7, 2020. https://www.spine.org/Portals/0/assets/downloads/Publications/NASSInsider/NASSGuidanceDocument040320.pdf
8. Burke JF, Chan AK, Mummaneni V, et al. Letter: The Coronavirus Disease 2019 Global Pandemic: A Neurosurgical Treatment Algorithm. *Neurosurgery*. Published online April 3, 2020. doi:10.1093/neuros/nyaa116
9. Cenzato M, DiMeco F, Fontanella M, Locatelli D, Servadei F. Editorial. Neurosurgery in the storm of COVID-19: suggestions from the Lombardy region, Italy (ex malo bonum). *J Neurosurg*. Published online April 10, 2020:1-2. doi:10.3171/2020.3.JNS20960
10. Eichberg DG, Shah AH, Luther EM, et al. Letter: Academic Neurosurgery Department Response to COVID-19 Pandemic: The University of Miami/Jackson Memorial Hospital Model. *Neurosurgery*. Published online April 11, 2020. doi:10.1093/neuros/nyaa118
11. Arnaout O, Patel A, Carter B, Chiocca EA. Letter: Adaptation Under Fire: Two Harvard Neurosurgical Services During the COVID-19 Pandemic. *Neurosurgery*. Published online April 17, 2020. doi:10.1093/neuros/nyaa146
12. Lwu S, Paolucci EO, Hurlbert RJ, Thomas KC. A scoring system for elective triage of referrals: Spine Severity Score. *Spine J*. 2010;10(8):697-703. doi:10.1016/j.spinee.2010.05.011
13. St-Pierre GH, Jack A, Thomas K, Hurlbert JR, Nataraj A. Validation of the Calgary Spine Severity Score. *Spine J*. 2015;15(10):2182-2187. doi:10.1016/j.spinee.2015.06.005
14. Stahel PF. How to risk-stratify elective surgery during the COVID-19 pandemic? *Patient Saf Surg*. 2020;14(8). doi:10.1186/2Fs13037-020-00235-9
15. Galarza M, Gazzeri R. Letter: Collateral Pandemic in Face of the Present COVID-19 Pandemic: A Neurosurgical Perspective. *Neurosurgery*. Published online April 20, 2020.

doi:10.1093/neuros/nyaa155
16. Lee ZD, Chyi Yeu DL, Ang BT, Ng WH, Seow WT. Editorial. COVID-19 and its impact on neurosurgery: our early experience in Singapore. *J Neurosurg*. Published online April 2020:1-2. doi:10.3171/2020.4.JNS201026
17. Prachand VN, Milner R, Angelos P, et al. Medically Necessary, Time-Sensitive Procedures: Scoring System to Ethically and Efficiently Manage Resource Scarcity and Provider Risk During the COVID-19 Pandemic. *J Am Coll Surg*. Published online April 2020. doi:10.1016/j.jamcollsurg.2020.04.011
18. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. *J Chronic Dis*. 1987;40(5):373-383. doi:10.1016/0021-9681(87)90171-8
19. Bhatraju PK, Ghassemieh BJ, Nichols M, et al. Covid-19 in Critically Ill Patients in the Seattle Region — Case Series. *N Engl J Med*. Published online March 30, 2020:NEJMoa2004500. doi:10.1056/NEJMoa2004500
20. Goyal P, Choi JJ, Pinheiro LC, et al. Clinical Characteristics of Covid-19 in New York City. *N Engl J Med*. Published online April 17, 2020:NEJMc2010419. doi:10.1056/NEJMc2010419
21. Wang D, Hu B, Hu C, et al. Clinical Characteristics of 138 Hospitalized Patients With 2019 Novel Coronavirus–Infected Pneumonia in Wuhan, China. *JAMA*. 2020;323(11):1061. doi:10.1001/jama.2020.1585
22. 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(10229):1054-1062. doi:10.1016/S0140-6736(20)30566-3
23. Yang X, Yu Y, Xu J, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. *Lancet Respir Med*. Published online February 2020. doi:10.1016/S2213-2600(20)30079-5
24. Amin-Hanjani S, Bambakidis NC, Barker FG, et al. Editorial. COVID-19 and neurosurgical practice: an interim report. *J Neurosurg*. Published online April 2020:1-2. doi:10.3171/2020.4.JNS201099
25. Giorgi PD, Villa F, Gallazzi E, et al. The management of emergency spinal surgery during the COVID-19 pandemic in Italy. *Bone Joint J*. Published online April 23, 2020:xxx-xxx. doi:10.1302/0301-620X.102B6.BJJ-2020-0537
26. Xu S, Li Y. Beware of the second wave of COVID-19. *Lancet*. 2020;395(10233):1321-1322. doi:10.1016/S0140-6736(20)30845-X
27. Nickol ME, Kindrachuk J. A year of terror and a century of reflection: perspectives on the great influenza pandemic of 1918–1919. *BMC Infect Dis*. 2019;19(1):117. doi:10.1186/s12879-019-3750-8
28. Leung K, Wu JT, Liu D, Leung GM. First-wave COVID-19 transmissibility and severity in China outside Hubei after control measures, and second-wave scenario planning: a modelling impact assessment. *Lancet*. 2020;395(10233):1382-1393. doi:10.1016/S0140-6736(20)30746-7
29. Ehresman J, Ahmed AK, Lubelski D, et al. Assessment of a Triage Protocol for Emergent Neurosurgical Cases at a Single Institution. *World Neurosurg*. 2020;135:e386-e392. doi:10.1016/j.wneu.2019.12.005
30. Ahmed K, Zygourakis C, Kalb S, et al. Protocol for Urgent and Emergent Cases at a Large

Academic Level 1 Trauma Center. *Cureus*. 2019;11(1):e3973. doi:10.7759/cureus.3973
31. Chowdhury S, Nicol AJ, Moydien MR, Navsaria PH, Montoya-Pelaez LF. Is case triaging a useful tool for emergency surgeries? A review of 106 trauma surgery cases at a level 1 trauma center in South Africa. *World J Emerg Surg*. 2018;13(1):4. doi:10.1186/s13017-018-0166-5
32. Ibrahim GM, Tymianski M, Bernstein M. Priority Setting in Neurosurgery as Exemplified by an Everyday Challenge. *Can J Neurol Sci*. 2013;40(3):378-383. doi:10.1017/S0317167100014347
33. Ramakrishna R, Zadeh G, Sheehan JP, Aghi MK. Inpatient and outpatient case prioritization for patients with neuro-oncologic disease amid the COVID-19 pandemic: general guidance for neuro-oncology practitioners from the AANS/CNS Tumor Section and Society for Neuro-Oncology. *J Neurooncol*. Published online April 9, 2020. doi:10.1007/s11060-020-03488-7
34. Societies EA of N. EANS advice: Triaging non-emergent neurosurgical procedures during the COVID-19 outbreak. Published 2020. Accessed April 29, 2020. https://cdn.ymaws.com/www.eans.org/resource/resmgr/documents/corona/eans_advice2020_corona.pdf
35. Jean WC, Ironside NT, Sack KD, Felbaum DR, Syed HR. The impact of COVID-19 on neurosurgeons and the strategy for triaging non-emergent operations: a global neurosurgery study. *Acta Neurochir (Wien)*. Published online April 21, 2020. doi:10.1007/s00701-020-04342-5

Tables

Table 1: Spine surgery urgency scoring system

Table 2: Proposed timeframes for surgical treatment based upon urgency score

Figures

Figure 1. Screenshot of web-based calculator deployed based upon scoring system identified (https://jhuspine3.shinyapps.io/SpineUrgencyCalculator/)

Table 1: Spine surgery urgency scoring system

Neurological status	
Progression of symptoms	
Progressive symptoms	See "rapidity of progression"
Stable symptoms	0
Rapidity of progression	
<48hr	14
48hr-7d	10
1wk-1mo	8
>1mo	4
Myelopathy	4
With radiographic cord compression	2
With signal change	1
Radiographic cord compression without myelopathy	2
With signal change	1
Degree of impairment in ADLs or ambulation	
Baseline ambulation/ADLs	0
Newly impaired ambulation/ADLs	14
New inability to ambulate/perform ADLs	20
Spinal stability	
Stable	0
Potentially unstable	6
Chronic instability	10
Acute instability	20
High-risk post-operative complications	
Deep wound infection requiring surgery[†]	30
CSF leak requiring surgery[†]	30
New neurologic deficit	30
Malpositioned hardware with threat to vital structure[‡]	30
Medical comorbidities[§]	
0-2	0
3-4	-2
≥5	-4
Expected hospital course/discharge	
Current inpatient requiring operation for safe discharge	5
Patient will need ICU bed	-1
Expected stay	
Surgery can be performed in ASC or as outpatient surgery	2
Expected stay <2d	0
Expected stay 2-5d	-1
Expected stay >5d	-2
Will patient require post-op placement to SNF or inpatient rehab	
Yes	-4
Possibly/unknown	-2

No	0
Resource Limitations	
No resource limitations	0
ICU resources limited	-2
PPE shortage	-2
Local disease burden	
High	-4
Moderate	-2
Low	0

Key: ADL – activity of daily living; ASC – ambulatory surgery center; d – day; hr – hour; mo – month; SNF – skilled nursing facility; wk – week

†Whether the complication requires surgical intervention or can be treated with nonoperative management is made at the discretion of the attending surgeon

‡Vital structures include spinal cord, esophagus, trachea, aorta, lung,

§Medical comorbidities included: active malignancy, age >65, congestive heart failure, chronic kidney disease, chronic obstructive pulmonary disease, current cigarette or vape use, diabetes mellitus, history of myocardial infarction, interstitial lung disease, moderate-to-severe liver disease.

Table 1: Proposed timeframes for surgical treatment based upon urgency score

Points	Proposed Surgical Timeframe
22+	Emergent (e.g. ≤ 48 hours)
15-21	Urgent (e.g. within 2 weeks)
10-14	High-priority elective (e.g. within 6 weeks)
<10	Low-priority elective (e.g. delay until after COVID-19 crisis)

Key: COVID-19 – Coronavirus disease 2019

Spine Surgery Urgency Score

Neurological Status

Neurological Progression: Stable

Myelopathy: No

Radiographic Cord Compression: None

Degree of Impairment in ADL/ambulation: Baseline ambulation/ADLs

Spinal Stability

Access a Supplementary Spinal Stability Calculator: None

Spinal Stability: Stable

Presenting with High-Risk Postoperative Complication

No

Medical Comorbidities

- [ ] Age>65 years
- [ ] COPD
- [ ] CHF
- [ ] Prior MI
- [ ] Diabetes
- [ ] CKD
- [ ] Current cigarette/vape use
- [ ] ILD
- [ ] Active DVT/PE
- [ ] Ongoing malignancy
- [ ] Moderate-to-severe liver disease
- [ ] Immunocompromised

Likely Hospital Course

Current Inpatient Requiring Operation for Safe Discharge: No

Expected Length of Stay: <2d

Needs ICU Bed: No

Patient Requires Postop Placement in SNF or Inpatient Rehab: No

Resource Availability

- [ ] ICU resources limited
- [ ] PPE shortage

Local Disease Burden

Low

Points	Result	Timing
0	The recommended timing of surgical treatment is	Low-priority elective (e.g. delay until after crisis)

Points	Timeframe
22+	Emergent (e.g. within 48 hours)
16-21	Urgent (e.g. within 2 weeks)
10-15	High-priority elective (e.g. within 6 weeks)
<10	Low-priority elective (e.g. delay until after crisis)

Abbreviations

AANS	American Association of Neurological Surgeons
ACS	American College of Surgeons
ADL	Activities of daily living
ARDS	Acute Respiratory Distress Syndrome
ASIA	American Spinal Injury Association
CDC	Centers for Disease Control and Prevention
CMS	Centers for Medicare and Medicaid Services
CNS	Congress of Neurological Surgeons
COVID-19	Coronavirus disease 2019
ICU	Intensive Care Unit
PPE	Personal protective equipment
SNO	Society for Neuro-Oncology

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