

Letter: A Guide to the Prioritization of Neurosurgical Cases After the COVID-19 Pandemic

To the Editor:

In anticipation of a surge in patients with the coronavirus disease of 2019 (COVID-19), neurosurgical patients across the majority of the United States with nonemergent conditions had their elective surgery postponed indefinitely. In preparation for the reopening of the surgical system and trying to prioritize which cases should go first, we produced a system by using the Delphi method to achieve general consensus. Neurosurgeons actively practicing in 2 separate geographic regions of the United States where “black level” COVID-19 surges occurred (the New York Metropolitan Area and Detroit, Michigan) participated in the process. We categorized a total of 86 unique neurosurgical scenarios into 6 tiers of priority and reached a consensus (>75% agreement) or majority opinion (>50%) on the timing of surgery on all except 1 case type (central cord syndrome). Here we present a guide that can assist neurosurgical departments prioritize the *relative urgency* of cases, whether it be due to a pandemic or any other scenario where the normal workflow has been severely disrupted.

INTRODUCTION

After the World Health Organization (WHO) declared COVID-19 a global pandemic in March, 2020, surgical departments throughout the United States were required to cancel all elective surgery by executive order. The time sensitivity and necessity of nonemergent surgery was deferred to the local level. Algorithms were developed to triage emergent, urgent, and elective cases in order to divert limited resources to the care of COVID-19 patients.¹⁻³ When hospital systems in the New York and Detroit Metropolitan Areas experienced “black level” surges of COVID-19 patients, all except for the most emergent cases were put on indefinite hold.¹

By late April 2020, the number of new COVID-19 cases being admitted daily plateaued in these 2 regions and hospitals started planning for the recovery effort. This included addressing all nonemergent surgery that had been postponed, along with the normal inflow of new surgical cases. Meanwhile, as the COVID-19 crisis persisted, albeit at a lower level, this continued to severely limit resources. Not surprisingly, there were discussions regarding the appropriate prioritization and timing of neurosurgical cases.

Here we provide a consensus developed with the Delphi method on the timing of surgery in a wide variety of neurosurgical conditions. This guide will be utilized to assist our institutions in prioritizing surgery in a rational manner. We believe that this guide could be useful to other departments, both neurosurgical and otherwise, as they emerge from the COVID-19 pandemic, or other major disruptions.

METHODS

Consensus Strategy for Neurosurgical Case Prioritization

Participants in the expert panel were invited based on 4 requirements: (1) attending neurosurgeon (2) in active practice in an area of the United States where “black level” surges had been occurring as a direct result of the COVID-19 crisis, (3) indefinite cancellation of their elective cases, and (4) no clear timeline to return to elective practice yet announced by their institutions.^{1,4} Two disparate regions of the country were selected (New York City and Detroit Metropolitan Areas) in an effort to avoid regional biases or local practice variations that may exist. Neurosurgeons were invited to voluntarily participate in the survey in order to establish expert consensus about the timing of neurosurgical intervention.

Preparation of Delphi Questionnaire and Survey Delivery

Participants provided their name, subspecializations, and years of experience as an attending neurosurgeon. Respondents were required to indicate the appropriate *timing* of surgery in the most frequently encountered surgical scenarios from 6 major subspecialties in neurosurgery (trauma/other, tumor, cerebrovascular, spine, pediatrics, and functional/epilepsy). A total of 86 distinct neurosurgical scenarios were presented to each participant. They were instructed to assume that in every scenario the patient definitely required surgery. Timeframes to perform the appropriate intervention were divided into 6 tiers: (1) emergent “life or limb” or within 24 h, (2) within 48 h, (3) within 1 wk, (4) within 2 wk, (5) within 4 wk, and (6) postcrisis or after 4 wk. Participants were provided an opportunity to provide anonymous comments and/or to not answer a particular question if they felt that they could not appropriately contribute an expert opinion in that subspecialty.

Consensus for each question was predefined as an “agreement among 75% of the experts.” After the first round of surveys, all participants received a copy of their answers as well as the overall results and anonymous comments. The second survey was delivered 5 d later and participants were asked to reassess scenarios in which a consensus was not reached. Response averages were determined and scenarios that then met the threshold of 75% were considered as having achieved consensus. Scenarios that did not meet the 75% agreement threshold but did achieve a simple majority (>50%) were reported as a “majority opinion.” Scenarios with less than 50% agreement were considered as “inconclusive or disagreement among experts.”

RESULTS

Twenty-two neurosurgeons accepted the invitation to participate in the Delphi study (14 from the New York and 8 from the Detroit Metropolitan Areas). The final panel of neurosurgeons reported subspecializations in trauma (12%), tumor (16%), vascular (12%), spine (23%), pediatrics (5%), functional/epilepsy (7%), and general neurosurgery (26%). Years of experience were a mean of 15.8 ± 10.5 yr.

A total of 67 of the 86 unique surgical scenarios (78%) reached the predefined consensus threshold of 75% agreement among

TABLE. Summarized Neurosurgical Case Scenarios

	Emergent or <24 h	<48 h	<1 wk	<2 wk	<4 wk	Prior hospital crisis or >4 wk	No. of responses
Trauma/other							
75% consensus agreement: 13/18 scenarios (72%)							
>50% majority agreement: 18/18 scenarios (100%)							
Average response rate: 89%							
Acute subdural hematoma with neurological decline	100%	–	–	–	–	–	21
Acute subdural hematoma, stable neurological examination	89%	11%	–	–	–	–	19
Chronic subdural hematoma with neurological decline	90%	10%	–	–	–	–	21
Chronic subdural hematoma, stable neurological examination	–	32%	68%	–	–	–	19
Epidural hematoma	100%	–	–	–	–	–	21
Intracranial hematoma with neurological decline	100%	–	–	–	–	–	21
Intracranial hematoma with stable neurological examination	11%	83%	6%	–	–	–	18
Decompressive craniectomy for stroke	95%	5%	–	–	–	–	21
Subdural empyema	80%	20%	–	–	–	–	21
Intracranial abscess	32%	68%	–	–	–	–	19
Infected cranial wound requiring washout	26%	74%	–	–	–	–	19
Depressed skull fracture requiring surgery	32%	63%	–	0%	0%	5%	19
Cranioplasty	–	–	5%	5%	15%	75%	21
Adult ventricular peritoneal shunt failure	83%	11%	6%	–	–	–	18
Ventricular shunt for normal pressure hydrocephalus	–	–	–	–	17%	83%	18
Repair of cranial CSF leak	6%	89%	6%	–	–	–	18
Placement of lumbar drain for CSF diversion	32%	68%	–	–	–	–	19
Chiari decompression	–	–	–	–	5%	95%	21
Vascular							
75% consensus agreement: 15/17 scenarios (88%)							
>50% majority agreement: 17/17 scenarios (100%)							
Average response rate: 84%							
Craniotomy for ruptured aneurysm	95%	5%	–	–	–	–	20
Endovascular treatment for ruptured aneurysm	95%	5%	–	–	–	–	20
Mechanical thrombectomy	95%	5%	–	–	–	–	20
Diagnostic cerebral angiogram (inpatient evaluation)	–	88%	6%	–	–	6%	18
Diagnostic cerebral angiogram (outpatient evaluation)	–	–	–	–	–	100%	18
Ventricular shunt post ruptured vascular lesion	6%	11%	83%	–	–	–	18
Treatment for ruptured AVM/AVF	78%	6%	11%	6%	–	–	18
Treatment for ruptured cavernoma	6%	6%	6%	6%	6%	72%	18
Treatment for CC fistula	–	19%	75%	–	–	6%	18
Carotid stenting (symptomatic)	–	7%	80%	–	–	13%	17
Carotid stenting (asymptomatic)	–	–	–	6%	–	94%	18
Carotid endarterectomy (symptomatic)	–	6%	69%	13%	–	13%	18
Carotid endarterectomy (asymptomatic)	–	–	–	–	–	100%	18
Treatment for unruptured aneurysm	–	–	–	–	6%	94%	18
Treatment for unruptured AVM/AVF	–	–	–	–	–	100%	18
Treatment unruptured cavernoma	–	–	6%	–	11%	83%	20
Extracranial-intracranial bypass	–	–	6%	–	–	94%	18
Functional							
75% consensus agreement: 7/9 scenarios (78%)							
>50% majority agreement: 9/9 scenarios (100%)							
Average response rate: 77%							
Baclofen pump failure	71%	12%	18%	–	–	–	17
Implantable pulse generator/device battery change	–	–	13%	–	53%	33%	15
Dorsal column stimulator placement	–	–	–	–	7%	93%	15
Laser interstitial thermal therapy for seizure	–	–	–	–	7%	93%	15
Insertion of pain pump	–	–	–	–	6%	94%	18
Deep brain stimulation	–	–	–	–	6%	94%	18

	Emergent or <24 h	<48 h	<1 wk	<2 wk	<4 wk	Prior hospital crisis or >4 wk	No. of responses
Resection of seizure focus	–	–	–	–	17%	83%	18
Microvascular decompression	–	–	–	6%	11%	83%	18
Stereo-EEG or craniotomy for grid placement	–	–	–	–	17%	83%	18
Spine							
75% consensus agreement: 13/17 scenarios (76%)							
>50% majority agreement: 16/17 scenarios (94%)							
Average response rate: 88%							
Cauda equina	90%	10%	–	–	–	–	20
Decompression for acute spinal cord injury	90%	10%	–	–	–	–	20
Spinal epidural hematoma	100%	–	–	–	–	–	20
Nonosseous tumor with neurological decline (<48 h)	68%	21%	5%	–	5%	–	19
Unstable fracture, incomplete neurological injury (<48 h)	86%	14%	–	–	–	–	20
Unstable fracture, complete neurological injury	11%	21%	68%	–	–	–	19
Unstable spine fracture without neurological decline	11%	11%	79%	–	–	–	19
Central cord syndrome	11%	26%	47%	–	16%	–	19
Pathological fracture with neurological decline (<48 h)	89%	11%	–	–	–	–	19
Pathological fracture without neurological decline	–	11%	74%	16%	–	–	19
Spinal abscess with neurological decline (<48 h)	95%	–	5%	–	–	–	20
Spine OM and/or discitis, failed nonsurgical treatment	–	5%	95%	–	–	–	19
CSM with neurological decline (<48 h)	–	84%	11%	–	5%	–	19
CSM with neurological decline	–	–	–	–	21%	79%	19
Degenerative spine without neurological decline	–	–	–	–	10%	90%	20
Degenerative spine with neurological decline (<48 h)	–	79%	11%	5%	5%	–	19
Deformity, nontraumatic/nonpathological	–	–	–	–	5%	95%	20
Tumor							
75% consensus agreement: 9/13 scenarios (78%)							
>50% majority agreement: 13/13 scenarios (100%)							
Average response rate: 82%							
Extra- or intra-axial tumor with neurological decline	16%	74%	11%	–	–	–	19
Extra- or intra-axial tumor with hydrocephalus	16%	21%	63%	–	–	–	19
Intra-axial tumor with shift	–	5%	89%	5%	–	–	19
Intra-axial tumor without shift	–	–	16%	74%	11%	–	19
Extra-axial tumor with shift	–	–	95%	5%	–	–	19
Extra-axial tumor without shift	–	–	–	–	6%	94%	18
Stereotactic brain biopsy	–	–	89%	6%	6%	–	18
Pituitary apoplexy (transnasal or transcranial approach)	85%	5%	10%	–	–	–	18
TSP for skull base lesion with optic compression	–	–	12%	18%	65%	6%	17
TSP for skull base lesion without optic compression	–	–	–	–	–	100%	17
CPA tumor without hydrocephalus and/or compression	–	–	6%	–	6%	88%	17
CPA tumor with hydrocephalus and/or compression	6%	–	82%	6%	6%	–	17
Insertion of Ommaya reservoir	–	6%	88%	–	–	6%	17
Pediatrics							
75% consensus agreement: 10/12 scenarios (83%)							
>50% majority agreement: 12/12 scenarios (100%)							
Average response rate: 81%							
Shunt failure with hydrocephalus	100%	–	–	–	–	–	20
Shunt failure without hydrocephalus	14%	14%	71%	–	–	–	17
Open myelomeningocele	86%	14%	–	–	–	–	17
Pediatric Ommaya reservoir insertion	14%	–	86%	–	–	–	17
Tumor with shift	7%	86%	7%	–	–	–	17
Tumor without shift	–	–	57%	29%	7%	7%	17
Craniosynostosis	–	–	–	–	7%	93%	17

TABLE. Continued.

	Emergent or <24 h	<48 h	<1 wk	<2 wk	<4 wk	Prior hospital crisis or >4 wk	No. of responses
Tethered cord	–	–	–	–	–	100%	17
Endoscopic third ventriculostomy for hydrocephalus	7%	–	86%	7%	–	–	17
Brain biopsy +/- endoscopic third ventriculostomy	–	7%	79%	7%	–	7%	17
Chiari malformation	–	–	6%	–	11%	83%	20
Laminectomy for selective dorsal rhizotomy	–	–	–	–	6%	94%	20

AVF, arteriovenous fistula; AVM, arteriovenous malformation; CC, cavernous-carotid; CPA, cerebellopontine angle; CSF, cerebrospinal fluid; CSM, cervical spondylotic myelopathy; EEG, electroencephalography; OM, osteomyelitis; TSP, transphenoidal.

All surgical indications were considered to be met. Participants were asked to indicate the *timing* of surgical intervention. Percentage response of each Delphi scenario and average response rate are reported.

experts after 2 survey rounds. The rest reached a majority opinion (>50% agreement), except for 1 surgical scenario (central cord syndrome) that failed to reach agreement or majority opinion. Ten surgical scenarios reached 100% agreement on surgical timing. Depending on their expertise, several participants did not answer every scenario. Trauma/others had the highest average response rate (89%) and functional/epilepsy cases had the lowest average response rate (77%). The scenarios and distribution of responses are shown in the Table. With this consensus-building process, we were able to create a rational system by which the timing of the most common neurosurgical cases can be prioritized (Figure).

DISCUSSION

In anticipation of the surge from COVID-19 patients, and in response to the executive government order, hundreds of neurosurgical procedures were postponed indefinitely at North Shore University Hospital in Manhasset, New York. Although recommendations started to appear in the literature regarding surgical triage during an ongoing crisis, there was limited guidance on how to prioritize surgical volume as hospitals emerged from the crisis and into the recovery phase, particularly as the backlog of patients waiting for surgery started to grow.⁵⁻⁹

Among the many considerations in the resumption of elective surgery were (1) the *urgency of the surgery*, and (2) the *relative prioritization* of cases.⁴⁻⁹ The authors were determined to demonstrate an approach to organizing this backlog with 2 goals in mind: (1) to ensure applicability to all neurosurgical subspecialties, and (2) to create a template that could be used in the future by other surgical departments.

The Delphi method was utilized to assess the timing of surgery. This method allows an expert panel to have their opinions evolve over subsequent rounds of surveys to reach a consensus. As demonstrated by neurosurgeons from 2 regions of the United States (experiencing the COVID-19 crisis in nearly the same severity and timeframe), consensus on the timing of neurosurgical scenarios could be achieved in 78% of presented surgical scenarios.^{10,11} Furthermore, a majority agreement was reached in every scenario that did not reach consensus with only 1 exception

(central cord syndrome). It should be noted that there is a wide range of opinions regarding the management of central cord syndrome.¹² Nonetheless, we were able to establish a guide for prioritization: Northwell Neurosurgical Prioritization Initiative (NNPI; Figure).

The Delphi method has its drawbacks, namely that it takes an extensive amount of time to complete. We found that with guidance, instruction, and encouragement from department leadership this can be accomplished in a timely manner. The authors performed a complete Delphi study in under 9 d and believe this was a timely accomplishment, especially in the setting of the COVID-19 crisis.

Expert panel selection is also critical to a successful Delphi study and frequently cited as a shortcoming.^{10,11} Regional biases, habits, or geographic trends in medicine may exist in each surgical specialty. A bias may develop if the expert panel consists of members from one specific geographic region and the opinion may not be applicable to other regions. The authors addressed this by assembling an expert panel that incorporated neurosurgeons from 2 different regions of the nation undergoing a similar crisis situation (“black level” COVID-19 surge). Both hospital systems experienced a surge of patients well beyond their baseline institutional capacity. This provided an expert panel that, regardless of region, was homogenous in its experience and circumstances.

At the time of manuscript preparation, we were not aware of a unified neurosurgical guide agreed upon by experts that conveys the prioritization of neurosurgical cases. Our guide, NNPI (Figure), should serve that purpose. The resulting prioritization of neurosurgical cases allows neurosurgical departments to clearly and effectively communicate with their hospitals and surgical teams to organize the deluge of cases that may be encountered in the post-locked-down period. For emergency cases that require surgery within 48 h, there will likely be little resistance to accommodate them within the scheduling system. However, for less urgent cases, faculty within the neurosurgery department will be competing with each other and with other surgical services. Other considerations include the availability of operating rooms, staff, nurses, anesthesia, recovery/intensive care unit (ICU)/floor beds, medications, and ventilators.

	Trauma	Tumor	Vascular	Spine	Pediatrics	Functional
Tier 1: Emergent or < 24 hours	<ul style="list-style-type: none"> - Acute subdural hematoma (SDH) with neurological decline - Acute subdural hematoma with stable neurological exam - Chronic SDH with decline - Intracranial hematoma (IPH) with neurological decline - Subdural empyema - Epidural hematoma - Adult ventricular shunt failure 	<ul style="list-style-type: none"> - Pituitary apoplexy, transcranial or transphenoidal (TSP) 	<ul style="list-style-type: none"> - Craniotomy for ruptured aneurysm - Endovascular for ruptured aneurysm - Mechanical thrombectomy - Decompressive craniectomy for stroke - Ruptured arteriovenous malformation and/or arteriovenous fistula (AVF) (f) 	<ul style="list-style-type: none"> - Cauda equina - Decompression for acute spinal cord injury - Spinal epidural hematoma - Spinal abscess with neurological decline (<48 hours) - Unstable fracture with incomplete neurological injury (<48 hours) - Pathological spine fracture with neurological decline (<48 hours) - Non-osseous spine tumor with neurological decline (<48 hours)– 	<ul style="list-style-type: none"> - Ventricular shunt failure with hydrocephalus - Open myelomeningocele 	<ul style="list-style-type: none"> - Baloferon pump failure–
Tier 2: < 48 hours	<ul style="list-style-type: none"> - Repair of cranial CSF leak - IPH with stable exam - Depressed skull fracture* (a) - Intracranial abscess* - Infected cranial wound requiring surgical washout* - Lumbar drain for cerebrospinal fluid leak diversion* 	<ul style="list-style-type: none"> - Extra-axial or intra-axial tumor with neurological decline 	<ul style="list-style-type: none"> - Diagnostic angiogram for in-patient evaluation 	<ul style="list-style-type: none"> - Cervical myelopathy with neurological decline (<48 hours) - Degenerative spine with neurological decline (<48 hours) 	<ul style="list-style-type: none"> - Tumor with shift (c) 	
Tier 3: < 1 week	<ul style="list-style-type: none"> - Chronic SDH with stable exam* 	<ul style="list-style-type: none"> - Intra-axial tumor with shift (c) - Extra-axial tumor with shift - Stereotactic brain biopsy - Ommaya reservoir - Cerebellopontine angle (CPA) tumor with hydro and/or brainstem compression - Extra-axial or intra-axial tumor with hydrocephalus* (d) 	<ul style="list-style-type: none"> - Ventricular shunt placement after ruptured vascular lesion - Treatment of carotid-cavernous fistula - Carotid stenting (symptomatic) - Carotid endarterectomy (symptomatic)– 	<ul style="list-style-type: none"> - Unstable fracture without neurological decline - Unstable fracture with complete neurological injury* - Pathological spine fracture without neurological decline - Spine osteomyelitis and/or discitis failed non-surgical management 	<ul style="list-style-type: none"> - Pediatric Ommaya (ETV) for hydrocephalus - Tumor biopsy (open or endoscopic) +/- ETV - Ventricular shunt failure without hydrocephalus* - Tumor without shift– (c) 	
Tier 4: < 2 weeks		<ul style="list-style-type: none"> - Intra-axial tumor without shift 				
Tier 5: < 4 weeks		<ul style="list-style-type: none"> - TSP with optic compression* (e) 				<ul style="list-style-type: none"> - Implantable generator/ device battery change–
Tier 6: Post hospital crisis or > 4 weeks	<ul style="list-style-type: none"> - Cranioplasty - Shunt for normal pressure hydrocephalus - Chiari malformation (b) 	<ul style="list-style-type: none"> - Extra-axial tumor without shift - TSP without optic compression - CPA tumor without hydro and/or brainstem compression 	<ul style="list-style-type: none"> - Diagnostic angiogram for out-patient evaluation - Unruptured intracranial aneurysm - Unruptured AVM/AVF - Carotid stenting (asymptomatic) - EC-C bypass (f) - Ruptured cavernoma* 	<ul style="list-style-type: none"> - Degenerative spine without neurological decline - Cervical myelopathy without neurological decline - Deformity spine surgery non-traumatic, non-pathologic 	<ul style="list-style-type: none"> - Chiari malformation (b) - Laminectomy for selective dorsal rhizotomy - Craniostomy (g) - Tethered cord 	<ul style="list-style-type: none"> - Insertion of pain pump - Deep brain stimulation - Resection of seizure focus - Dorsal column stimulator - Microvascular decompression (h) - Stereotaxic or craniotomy for grid placement - Laser interstitial thermal therapy (LITT) for seizure
No agreement or majority reached	None	None	None	Central cord syndrome	None	None
<p>Key: * at least simple majority reached (> 50%) but no consensus with some experts operating more promptly</p>						
<p>Delphi Study Expert Panel Comments:</p> <p>(a) open depressed skull fracture should be operated on within 24 hours, closed can potentially wait</p> <p>(b) encouraged to operate sooner (< 4 weeks) in the presence of syringomyelia</p> <p>(c) type of suspected tumor would be important in making the decision for surgical timing during a crisis or pandemic</p> <p>(d) bedside ventriculostomy may be a temporizing measure to stabilize patient until surgery can be safely performed</p> <p>(e) may consider operating sooner depending on visual field exam</p> <p>(f) need to consider involvement and availability of endovascular services</p> <p>(g) endoscopic craniostomy has short window of effectiveness. Missing window would place the patient at a higher risk of needing secondary procedure</p> <p>(h) except in cases of extremus with trigeminal neuralgia attack (patients are admitted and done within 48 hours generally)</p> <p>(i) EC-C bypass depends on indication. For ischemia or symptomatic aneurysm might need to be done within 1-2 weeks. If for progressive neurological decline despite maximal therapy then would do it earlier preferably within 24-48 hours of known failure of medical therapy.</p>						

FIGURE. Northwell Neurosurgical Prioritization Initiative (NNPI). Summary of timing in the most frequently encountered scenarios of neurological surgery utilizing the Delphi method. Surgical scenarios in italics did not reach a consensus agreement but did reach a majority opinion (> 50%). Anonymous comments from the expert panel included.


The main limitation of our protocol is that it relies on expert opinion. The case categories are by nature broadly defined and cannot take into account individual patient characteristics. Exceptions to this guide may occur when a surgeon believes the clinical situation requires more urgent attention than would be suggested by this guide, provided that a convincing case can be made for such an exception.

CONCLUSION

The relative urgency of different neurosurgical interventions can be achieved by an expert panel using the Delphi method. This guide can assist departments in effectively prioritizing nonemergent and elective surgery during the recovery from a pandemic or other major healthcare disruption. Furthermore, this approach can easily be adopted by other surgical disciplines.

Disclosures

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Justin G. Thomas, DO*
Shashank Gandhi, MD‡
Timothy G. White, MD 
Christian Jocelyn, MHA‡
Teck M. Soo, MD*
Mark Eisenberg, MD‡
Michael Schulder, MD‡
Raj K. Narayan, MD‡

*Division of Neurosurgery
 Michigan State University College of Human Medicine
 Ascension Providence Hospital
 Southfield, Michigan

‡Department of Neurosurgery
 The Donald and Barbara Zucker School of Medicine at
 Hofstra/Northwell
 North Shore University Hospital
 Manhasset, New York

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