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Challenges to Neurosurgery During the Coronavirus Disease 2019 (COVID-19) Pandemic

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The coronavirus disease 2019 pandemic has presented a massive burden to most health care systems across the globe. The demand for intensive care unit capacity in particular has increased significantly, and hospitals in most affected regions have struggled to cope. The focus of health care activity has shifted to the pandemic, with a negative impact on the management of other conditions.

Neurosurgery, like most specialties, has been drastically affected but, arguably, warrants special considerations because many of the treatments required are time-critical. Lack or delay of appropriate intervention may lead, for an individual patient, to permanent neurologic injury and a significant decline in function and quality of life, or even death.

In this report, we consider the challenges that neurosurgeons currently face in relation to the pandemic and are likely to face in the foreseeable future. The challenges are multifaceted with practical, ethical, legal, and other implications. These include re-deployment of staff to areas outside neurosurgery, treatment priority setting, ethical decision-making and risk of moral injury, as well as medicolegal risks, financial uncertainties and implications for training, research, and global health work. As well as patients, these challenges will affect neurosurgeons as doctors and as humans. The international neurosurgical community has a moral duty to contribute to the global response to the COVID-19 crisis, but also to retain a duty to care for individual patients.

INTRODUCTION

The coronavirus disease 2019 (COVID-19) outbreak was declared a Public Health Emergency of International Concern on January 30, 2020.¹ Health care systems around the world were largely unprepared to deal with the potentially overwhelming surge of affected patients, especially those requiring mechanical ventilation. The World Health Organization has published a range of interim guidelines for all countries on how to prepare for the pandemic, emphasizing the need for intensive care unit (ICU) capacity.² Governments and hospitals have needed to redirect resources in an attempt to expand ICU capacity and meet the growing demand. Current epidemiologic modeling is based on recent viral outbreaks such as Severe Acute Respiratory Syndrome, Middle-East Respiratory Syndrome, and influenza but cannot be regarded as robust until more data are gathered about COVID-19 itself.³ It has, however, become clear that policymakers must prepare for a health care crisis that may last up to 1, possibly 2 years. The current epicenters are in Europe and North America, and the epidemiologic curve was predicted to peak in most affected countries between April and May, with possible further epidemic waves thereafter.⁴

The COVID-19 pandemic undoubtedly has the capacity to overwhelm health care systems, even in affluent societies. This is due not only to the unprecedented surge of patients but also a likely concomitant and high infection rate among doctors and nurses. About 10% of the reported cases in China and Italy have been among health care workers.⁵ In our hospital, a cohort of 538 asymptomatic staff members participated in a UK study that aims to ascertain the prevalence of asymptomatic viral carriage in health care workers. As we passed through the initial surge of COVID-19 cases, nearly one quarter of them were found to be antibody positive by enzyme-linked immunosorbent assay testing, and only

Key words

- Coronavirus
- COVID-19
- Neurosurgery
- Pandemic

Abbreviations and Acronyms

COVID-19: Coronavirus disease 2019

ICU: Intensive care unit

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3% were positive to testing by polymerase chain reaction. Just more than one third of this cohort had previously self-isolated at home with symptoms of COVID-19 (unpublished data).

Required increases in hospital capacity include, primarily, expansion of ICU and respiratory wards, both as regarding to beds and appropriately trained medical and nursing staff. Preparation is urgent, but options are limited. The pragmatic approach has been to redeploy existing bed capacity and reconfigure health care workforces. Outpatient activity has been reduced and nonurgent diagnostic tests and elective treatments have been postponed. Such changes have inevitably reduced hospitals' capacity to manage other conditions.

Neurosurgical care is clearly impacted by these COVID-19 responses. Elective surgical procedures have been cancelled so that operating theater staff and equipment can be used for critical care. Outpatient activity has been reduced, both to redirect resources and to lower transmission of the disease by decreasing the footprint in hospitals. Neurosurgeons have faced unprecedented challenges, including working outside their area of expertise, prioritization of neurosurgical cases with limited resources, facing new ethical dilemmas, and being exposed to moral injuries, medicolegal risks and, in some cases, to financial uncertainties. Neurosurgical training and research also have been reduced, and non-COVID-related global health work has been suspended (Table 1). New working models and systems have needed to be developed, within a short period of time, to ensure safe neurosurgical practices as far as possible.⁶ Neurosurgeons have needed to rise to these challenges and take collective actions, in their local settings, to mitigate the negative consequences of the pandemic.

REDEPLOYMENT

In the United Kingdom, all elective work, neurosurgical and otherwise, has been curtailed, to allow for reallocation of resources at the frontline of the response. Some emergency work has also decreased, as a direct consequence of government imposed social distancing rules. For example, we have seen a reduced volume of neurotrauma from road traffic collisions and interpersonal violence. Consequently, the neurosurgical workforce has been engaged in task shifting and task sharing.⁷ These radical changes have required rapid retraining of neurosurgical staff, not just to manage the initial COVID-19 surge but also to support a maintenance phase for the duration of the pandemic.

Neurosurgeons are well aware of the importance of maintaining good tissue oxygenation, to ensure viability of central nervous system but, beyond this, may feel uncomfortable in managing severe pneumonia or ventilated patients, let alone renal, lymphoreticular, and other organ system failures that affect patients who are more severely affected by COVID-19. In our hospital, focused training and collaboration with other specialties has nevertheless helped us to build resilient teams able to provide appropriate care to patients. Areas in which transferrable skills can be applied are being explored, for example, application of theater-based lifting and patient transfer skills, in providing a "proning" service for ventilated patients with acute respiratory distress syndrome. We have elected to redeploy trainees initially, leaving senior staff to assume a significant component of providing the care of neurosurgical patients. Although not required to date, we have

the option of senior trainees filling gaps in neurosurgical duty rotations and retired neurosurgeons may be asked to return to work. Medical students have taken up some junior, ward-based roles. Above all, we have found that flexibility in our approach is crucial.

A potential risk of specialist staff being exposed to long periods of redeployment is deskilling. As with all surgical specialties, neurosurgery is a craft discipline, and regular exposure to operative practice is important to maintain highly specialized technical skills. Neurosurgeons must strive to maintain delivery of safe, urgent, and emergency neurosurgical care, despite the need for redirection of many resources in the response to COVID-19.

PRIORITY SETTING

Appropriate resource allocation requires that health care systems function fairly and protect patient safety.⁸ Priority setting is centered on the concept of justice, which implies that fair distribution of available resources is based primarily on clinical needs. Up until the pandemic, most neurosurgical departments have been able, for the most part, to control allocation of their finite resources. Local mechanisms have been in place to ensure fair and ethical decision-making. In most settings, especially in the developed world, neurosurgical patients have not been competing with other patients for resources. Those at a high risk of imminently developing neurologic disability have been prioritized. In low- and middle-income countries, priority setting has usually been more complex, due to more limited resources.

The situation now has changed dramatically. Priority setting has shifted to rest at higher health management levels. Resources have needed to be redistributed on a massive scale, at very short notice, primarily toward ICU capacity. Surgical specialties can therefore no longer function autonomously. Elective tertiary care has diminished significantly, mainly due to the unavailability of operating theater lists. Neurosurgery is particularly affected, not least because many modern-day neurosurgical procedures are dependent upon availability of ICU capacity for postoperative care.

The peak of the present crisis, in individual countries and states, is likely to put local neurosurgeons under pressures not previously encountered in normal times. In terms of obtaining the best benefit from finite resources, priority may need to shift from treating the sickest to treating those most likely to respond to aggressive intervention. Parameters that were irrelevant or inappropriate previously may now direct our decisions to treat. Factors may include the availability of drugs, equipment, theater time, and ICU capacity but also life expectancy after surgery and age of the patient. The threshold to intervene neurosurgically will likely increase. Those particularly disadvantaged by these factors are elderly, vulnerable, and frail people. A particular consideration for this group of patients, in the context of neurosurgical pathology, is their concomitant greater risk of mortality from COVID-19 if they are being treated in a COVID-positive hospital. There is clear pressure for neurosurgeons to avoid bringing these patients into hospital, and standard treatments may therefore need to be replaced by suboptimal treatment methods. The risks of complications and unfavorable outcomes will inevitably increase.

By way of example, in our hospital, some patients with a radiologic diagnosis of malignant brain tumor were not offered

Table 1. Challenges and Considerations Related to Neurosurgical Practice During the COVID-19 Pandemic

Challenges	Considerations
Redeployment	<ul style="list-style-type: none"> ■ Appropriate training for work outside neurosurgery ■ Consideration of transferable skills for redeployment ■ Risk of deskilling if redeployment lasts long periods ■ Maintenance of minimum staff for safe neurosurgical practice
Priority setting	<ul style="list-style-type: none"> ■ Priority for time-critical neurosurgical conditions ■ Adoption of substandard treatment to cope with demand ■ Prognosis for many neurosurgical conditions is better than severe COVID-19 ■ Risk assessment of coronavirus transmission to neurosurgery staff and patients
Ethical challenges	<ul style="list-style-type: none"> ■ Risk of health care injustices against neurosurgery patients ■ Equitable access to health care based on clinical needs ■ Exposure to moral injuries/ violation of ethical code ■ Development of guidance to inform ethical dilemmas
Medicolegal and financial implications	<ul style="list-style-type: none"> ■ Potential increase in clinical negligence claims ■ Exposure to legal risk while working outside neurosurgery ■ Shared and timely decision-making to mitigate individual risk ■ Extension of indemnity cover for the additional liabilities ■ Reduced revenue in countries where remuneration is based on neurosurgical activity/ volume and from impact on private practice
Supporting professional activities	
Training	<ul style="list-style-type: none"> ■ Impact on neurosurgical training pathway and professional development ■ Distance-learning tools to be used for training
Research	<ul style="list-style-type: none"> ■ Clinical and laboratory research is reduced/ceased ■ New opportunities for neurosurgical research in relation to the pandemic
Global health	<ul style="list-style-type: none"> ■ Halt on global health missions during the pandemic ■ Increased demand in all affected countries due to backlog after the pandemic

COVID-19, coronavirus disease 2019.

surgery, as per our standard neuro-oncology pathway, but primary radiotherapy and/or chemotherapy instead. Withholding or delaying these and other neurosurgical procedures may result in significant neurologic impairment, or even death, in patients who would otherwise likely have faced a more favorable outcome. In particular, benign pathologies that cause raised intracranial pressure, or lesions that compress the brainstem, the optic apparatus, the spinal cord or the cauda equina, all have a time-critical component to their treatment. Such neurosurgical patients should not be unjustifiably disadvantaged over patients with COVID-19. The most common urgent neurosurgical conditions that require ICU admission are intracranial hemorrhage and traumatic brain injury, with mortality rate of between 30% and 45%.⁹⁻¹¹ For patients with COVID-19, the in-hospital mortality rate is also regrettably high, at 28% overall, but it is much greater, at more than 50%, among those requiring mechanical ventilation.¹²

In contrast, the prognosis for patients admitted to ICU following elective neurosurgical procedures is much more favorable.¹³

There are currently no data to suggest that critically ill neurosurgical patients have been denied access to treatment as a result of the COVID-19 outbreak. It is nevertheless still early and the full impact of the pandemic will not be established until after the crisis. Furthermore, the effects of COVID-19 will likely not be the same across the world. In some countries and cities the situation has been kept under control and, hopefully, may remain so throughout the duration of the pandemic. At the same time, some geographic locations have not reached their epidemic peak. Epidemiologic predictions are uncertain, and it remains unclear still quite how the pandemic will evolve. There are as yet no vaccines against COVID-19, and there is no imminent prospect of effective treatments becoming available.

Neurosurgeons should therefore continue to plan for worst-case scenarios.

Neurosurgical services may be further compromised by factors unlikely to be present in normal times, such as staff sickness and shortages of essential supplies. Plans should therefore be developed, with built-in resilience, to cope with fluctuations in demand on services and a unit's capacity to deliver these. Recent reports describing the reconfiguration of neurosurgical services in countries that have already experienced the peak of the pandemic have been valuable in guiding similar endeavors elsewhere.¹⁴⁻¹⁶ The sharing of knowledge and experience, among neurosurgeons, could certainly assist in the delivery of timely and effective responses in other countries.

Particular precautions are required in the case of endoscopic endonasal surgery, to mitigate the high risk of coronavirus transmission from aerosol generating procedures.¹⁷ Alternative surgical routes may be preferred, such as a craniotomy approach for central skull-base tumors. Transsphenoidal pituitary surgery is best avoided during this pandemic but, if it is deemed necessary in an individual case, then all theater staff should wear full personal protective equipment and exercise maximum caution to reduce aerosol spread.^{18,19} This should be the case irrespective of the results of the patient's COVID-19 screening, given the possibility of a false-negative result. Helpfully, many professional bodies are publishing guidelines on safe neurosurgical practice during the pandemic.^{20,21}

Neurosurgeons must continue to act as advocates for their patients' health needs during this pandemic, in particular their patients' rights to equitable access to health services. They cannot expect national or local policymakers to be fully aware of the needs of neurosurgical patients at the best of times, let alone during the current crisis. Neurosurgeons must seek to avoid needless morbidity and mortality, which could arise as unintended consequences of the response to COVID-19. Algorithms and contingency plans based on epidemiologically predicted surge levels must allow for the adequate care of neurosurgical patients, as well as facilitating the dynamic resource allocation required to meet the overall needs of the outbreak.²² As a minimum, access to operating theaters should be maintained for time-critical neurosurgical cases.

ETHICAL CHALLENGES

Any restriction of resources will affect significantly the bioethical framework in which neurosurgeons normally operate. Those used to working in affluent, well-resourced hospitals may well notice such effects more than will neurosurgeons who regularly function with more limited resources. Indeed, the former group may be less well equipped to cope with any resulting moral dilemmas, as they are used to giving even the sickest patients the greatest chance of recovery. The latter group, in contrast, will likely have more regular exposure to ethical conflicts.

Ethical medical practice is based on the premise that clinical decision-making is fair and morally justified.⁸ Health care systems must act fairly in balancing the competing claims on finite resources from different patient groups.²³ In the current climate, massive resources have rightfully been redeployed to address the needs for the COVID-19 patient group. Governments worldwide

will and already are being judged on their responses to this pandemic. Their prioritizing the management of COVID-19 is understandable, but this approach inevitably limits the access to health care by other patient groups, leading to "collateral damage" and potential inequalities in health care. Neurosurgeons must therefore establish strategies that recognize and mitigate potential health care injustices against their patients. They should monitor their therapeutic activity in the light of any new demands placed upon their services. They should continue to audit their own practices and outcomes, identifying and highlighting any shortcomings arising out of the current crisis. They should participate in higher-level, managerial decision-making, acting as advocates for their patients. They should ensure that any new knowledge gained is appropriately used in developing future solutions to public health issues such as COVID-19. Neurosurgeons also could engage usefully with patient peer-support groups and charities, to enhance awareness of their particular needs. It has been reported that many patients are currently unable to obtain, or are frightened of, accessing health care because of the pandemic.²⁴ Neurosurgical patients should not be left feeling neglected but, instead, be reassured that provisions are in place to address their needs.

Moral injury refers to the psychological distress suffered by health care workers that results from actions, or inactions, that violate an individual worker's ethical code.²⁵ Particularly relevant during wartime, challenging moral dilemmas are also likely to arise during the COVID-19 pandemic. Some clinical decisions may seem, at the time or at a later date, to be or have been unethical, unjustified, or going against guidelines. Treatment protocols, adopted in response to the crisis, may appear discriminatory and individual actions may not adhere to normal standards of professional conduct. Neurosurgeons who may be unable to help certain patients may feel guilty and demoralized. It should also be remembered that patients themselves are not invulnerable to such emotional traumas. What might be described as "reverse moral injury" could refer to feelings of guilt experienced by an individual who realizes that he or she is receiving neurosurgical, or other treatment, at the expense of a patient with COVID-19.

Although moral injury is not an illness, it can affect mental health. During the COVID-19 crisis in particular, hospitals and other health care providers need to provide adequate support to staff to reduce any psychological distress generated by such moral conflicts. Strategies that are transparent and clearly justified will help to ensure ethical decision-making and will help health care workers cope with moral dilemmas. Local protocols that promote shared responsibility, especially in making difficult decisions, such as withdrawing or withholding treatment, should be developed. Fields within neurosurgery, in which restriction of services may appear controversial, include trauma, oncology, vascular, and spinal pathologies. Subspecialty professional groups need to provide disease-specific guidance as to how neurosurgeons should act when extreme pressure limits normal services. Hospital ethics committees should develop mechanisms to support clinicians in ethically challenging situations. Such provisions will lessen the impact of moral injuries and promote psychological resilience. To date, staff in our unit appears to be coping well with these ethical challenges, supported by daily briefings from hospital

management and the provision of pastoral support when needed. Duty rotations of 4 days on, followed by 4 days off, have helped prevent any cases of “burn-out,” caused by over-work.

MEDICOLEGAL AND FINANCIAL IMPLICATIONS

Cancellations and delays in the provision of standard neurosurgical care will inevitably lead to poorer outcomes in some cases, thereby increasing the likelihood of clinical negligence claims arising. To mitigate this risk, neurosurgeons should strive to minimize, as far as possible, disruption of normal services. Where this is not feasible, novel working models need to be developed. These should include timely multidisciplinary input, with shared decision-making, to protect both surgeon and patient. Electronic communication systems certainly facilitate exchange of relevant clinical information, and information technology systems must ensure that sensitive data is securely encrypted.

Statutory health care regulators and professional bodies have issued guidelines in relation to the COVID-19 pandemic to promote consistency and fairness in care.^{20,21,26} Neurosurgical decisions that comply with national and local guidance are less exposed to criticism and medicolegal risk. Advice and support by the hospitals' legal services should be sought early when dealing with potential legal cases.

Existing indemnity arrangements may not be suitable to cover the medical workforce during the pandemic. Some added risks include retired staff returning to work and medical students joining the workforce. Health care providers must therefore provide additional indemnity cover for clinical negligence liabilities during this emergency period. The medicolegal risk should not act as a barrier to optimizing the response to the pandemic.

There are also financial implications for neurosurgery as a result of the pandemic, especially in countries in which the remuneration system is based on the number of health care activities or number of patients instead of a fixed salary. Sources of revenue like elective operations, outpatient consultations, and radiologic and laboratory investigations have reduced significantly, resulting in severe financial stresses to neurosurgical departments.²⁷ Moreover, in many countries, neurosurgeons work partly or exclusively in the private sector, which may be also affected to a variable degree, along with most sectors of the economy. The reduced workload may result in pay cuts, furloughs of essential staff, and concerns about future financial solvency. The expectation is that the financial impact will be temporary, but the speed and extent of recovery and subsequent economic consequences remain uncertain.

SUPPORTING PROFESSIONAL ACTIVITIES

Neurosurgeons, in common with all doctors, have a moral obligation to engage in the teaching and training of others. These and other activities, such as research and promotion of global health, may be regarded as nonessential during a pandemic such as COVID-19. As a result, in many areas, academic activities have been suspended. Yet the need for teaching, of the public and politicians, as well as health care workers, and for research into all aspects of COVID-19 (clinical, laboratory, and epidemiologic) has never been more urgent. So too is the need for the adoption of a global approach to the pandemic.

All medical specialties are likely to be affected by the current outbreak, but there are neurosurgery-specific considerations. At the hospital level, doctors in training are required to assist outside of their usual educational pathway. Redeployment will reduce their exposure to normal learning opportunities, in particular operating theater experience. This will impact, albeit temporarily, upon their career progression. In general, redeployment of trainees should be directed according to their specific skill set, but their remaining training needs should also be taken into account. For neurosurgical trainees, working in areas like ICU and emergency departments should, in practice, provide a more useful learning experience, as compared with their working on respiratory or infectious disease wards.

At national and international level, courses and conferences have been cancelled or postponed, with a potentially negative effect on professional development. At the same time, distance-learning options, like webinars and online applications, are ideal for delivering educational sessions in the current climate, as they comply with social distancing and restrictions on travel. There are also a number of web-based platforms that can provide high-quality neurosurgical teaching.^{28,29} Some neurosurgical programs have already started a transition to virtual training and plans are underway for more e-learning opportunities to be rolled out in the near future.^{30,31} The current crisis may at least give neurosurgical trainees some more time for private study and book work to augment their clinical experience.

Academic institutions have ceased some routine activities to allow academic clinicians to focus on provision of direct clinical care and for laboratories to assist with research and testing for COVID-19. New research opportunities have nevertheless emerged, and neurosurgeons should lead on projects that study the impact of the pandemic on their normal practice. It is also essential that accurate data are collected to capture all aspects of neurosurgical care, including impacts on treatment pathways, use of alternative treatments and outcomes. Among others, such studies may improve our understanding of the natural history of some neurosurgical pathologies, as well as the effect of COVID-19 on outcomes. The pandemic certainly lends itself to multicenter, international collaborations and researchers should act quickly and engage early.

Several global health activities have been reduced because of increased needs at national levels, as well as restrictions placed on international travel. Even in normal times, a deficit in the provision of essential neurosurgical care worldwide is estimated to affect more than 5 million people per year.³² It is reasonable to assume that this need for neurosurgical services will grow, and yet capacity to deliver such will likely lessen during the pandemic, due to the added pressure on already-deprived health care systems and reduced international support. The job of neurosurgeons in low- and middle-income countries is hard at best of times, and these added pressures will make their task harder. The pandemic will leave behind a significant backlog of untreated, elective neurosurgical cases in many parts of the world. Neurosurgeons in developed countries will be called upon to help less well-off societies as soon their own crises ease. They will then have to strike a balance between their obligations toward their own health care systems and employing institutions and their moral duty toward patients in more deprived countries.

CONCLUSIONS

Neurosurgeons in many countries are in a very particular predicament during this pandemic. They need to contribute to the response to COVID-19 and continue delivery of care for time-critical neurosurgical conditions. The challenges are massive and involve infrastructure and workforce considerations at multiple levels with limited data to inform decision-making. The pandemic is evolving, and it is not clear to what extent neurosurgery, or health care services in general, will revert to how they were before COVID-19, or what may become the “new normal.” The pandemic will likely have a lasting influence on the future of

health care, and it is vital that neurosurgeons develop a framework for addressing this crisis and similar global health challenges that may arise in the future.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Georgios Tsermoulas: Conceptualization, Writing - review & editing. **Athanasios Zisakis:** Writing - review & editing. **Graham Flint:** Writing - review & editing. **Antonio Belli:** Supervision, Writing - review & editing.

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