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The World of Neurosurgery Reimagined Post COVID-19: Crisis ↔ Opportunities

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The COVID-19 pandemic has impacted neurosurgery in unforeseeable ways. Neurosurgical patient care, research, and education have undergone extraordinary modifications as medicine and mankind have adapted to overcome the challenges posed by this pandemic. Some changes will disappear as the situation slowly recovers to a pre-pandemic status quo. Others will remain: This pandemic has sparked some long-overdue systemic transformations across all levels of medicine, including in neurosurgery, that will be beneficial in the future. In this paper, we present some of the challenges faced across different levels of neurosurgical clinical care, research, and education, the changes that followed, and how some of these modifications have transformed into opportunities for improvement and growth in the future.

IMPACT OF COVID-19 ON NEUROSURGERY IN NEW YORK CITY

The COVID-19 (coronavirus disease 2019) global pandemic was particularly fierce in New York City (NYC)—the city was hit early and, in large part due to a high population density, cases rapidly grew despite efforts at social distancing and economic shutdown.1 The incidence quickly escalated to 1000 cases per 100,000 people (1%), significantly surpassing most other areas in the United States.2 Deaths similarly soared; as of May 2, 2020, a total of 13,831 laboratory-confirmed COVID-19–associated deaths and 5048 probable COVID-19–associated deaths (i.e., without confirmatory polymerase chain reaction testing) were recorded in NYC.3 These numbers are increasing as cases continue to accumulate, albeit at a slower rate than during the peak of the crisis. NYC represented a special case for COVID-19, given its high hospital density. Emergency personnel were recruited to the city in an effort to staff newly created and rapidly converted intensive care units (ICUs) and pulmonary units. These efforts were successful, at least in part, thanks to national efforts at workforce redistribution, help from the Department of Defense, and a volunteer force willing to serve on the frontlines.4

Clearly, normalization of the health care system and return to the pre–COVID-19 status quo would be expected to take time. However, it is unclear whether the previous state of normalcy will ever be reached again. High hospital and ICU occupancy, for instance, have been measures of economic success in years past; going forward, lower occupancy could be required to create room for possible surges of COVID-19 cases.5–7 Similarly, elasticity, intended as the ability of a hospital to adapt to a rapidly changing patient population, will be a necessary feature of any health care system. In the pre-COVID era, opening a new unit often took years; the pandemic, however, forced such changes over weeks. Hospitals now have the know-how to rapidly convert and create new units on an “as-needed” basis, although these adaptations are rarely economically feasible, with numerous hospitals now facing financial struggles. It is clear that the health care system as a whole will need significant restructuring and reimagining.

In this paper, we focus on challenges and opportunities faced across different levels of neurosurgical clinical care, research, and education. We emphasize and discuss how, going forward, the challenges presented as a result of the COVID-19 crisis can be transformed into opportunities for growth and innovation across medicine in general and neurosurgery in particular.

IMPACT ON NEUROSURGICAL CLINICAL CARE

Innovations in Neurosurgical Practice

There have been many shifts, some tectonic, most positive, in the practice of neurosurgery as a result of the COVID-19 pandemic.

Key words

- COVID-19
- Neurosurgical innovations
- Pandemic

Abbreviations and Acronyms

COVID-19: Coronavirus disease 2019
ICU: Intensive care unit
NYC: New York City
OR: Operating room

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Clinical operations came to a near halt when the pandemic descended. Recovery from this assault on patients and providers required workarounds to be developed quickly. The sudden need for social distancing as a response to the rise in COVID-19 cases affected patient visits to neurological clinics. Many of our patients have to travel significant distances to reach our location in Manhattan, often spending hours in traffic to attend clinic visits. With the wide implementation of telehealth protocols because of COVID-19, it became clear that, in many cases, an in-person visit can be avoided. This has resulted in more rapid access for patients, decreased patient travel burden, and the possibility of reaching not only the underserved but also patients in remote locations with poor transportation.8-10 Of the many changes that COVID-19 inspired in the medical community, the increased availability and usage of telemedicine is one of the most likely to remain going forward, as it is favored by both patients and physicians and has been shown to be cost-effective.11

Although COVID-19 is not a primarily neurological condition, it significantly altered how we perform some neurosurgical procedures. For instance, endoscopic transsphenoidal surgeries were affected by the realization that aerosolization could put health care workers in danger. New protective measures had to be undertaken to minimize these risks.12,13 How local COVID-19 infection affects tissue healing is a matter of current research, with early reports of nasoseptal flap necrosis possibly associated with COVID-19–related coagulopathies impacting surgical management.13

The issue of hospital, ICU, and operating room (OR) capacity has been brought to the forefront by the pandemic as well. For instance, it became necessary to prioritize neurosurgical cases based on urgency and emergency, with elective cases being postponed in an effort to preserve patient safety and limit hospital traffic and exposure. These decisions about urgency and electivity of cases, especially in a field as complex as neurosurgery, can be hard to make and often require a dedicated decision-making panel. Global surveys have shown that this trend is not limited to NYC but, rather, common practice. COVID-19 has highlighted to the health care community that hospital staff and resources are finite and have to be deployed and used judiciously. These challenges also resulted in innovative protocol changes to manage ill patients; with OR and ICU beds limited, medical management of conditions that were usually treated surgically became more widespread. Future innovations in digital health platforms may also present new opportunities to improve not only testing and tracking of patients but also the organizing and delegating of hospital administrative tasks, such as planning surgical OR schedules and patient visits.

Future of Neurosurgical Critical Care in the Wake of the COVID Crisis
The COVID-19 crisis resulted in the overnight transformation of specialized ICUs into COVID ICUs, caring for patients with varying severities of acute respiratory and other systemic illnesses. As the initial surge passed in parts of the country, including NYC, and summer saw a relative lull, attention shifted to preparing for subsequent surges. Of particular importance was the issue of how to continue to provide specialized care to neurological patients in the face of the need for a unified effort to care for a high volume of COVID patients. Neurosurgical ICU leaders had to consider dedicating a portion of their units for COVID patients so as to separate them from other patients and lower the risk of cross-transmission. Because this would reduce the already-limited number of beds available for neurosurgical patients, strict prioritization of ICU space became of paramount importance. For instance, postoperative patients with less-complex care requirements might be allowed to recover either in the postoperative acute care unit or a step-down area until they were deemed ready to transition to the floor. In addition to freeing up ICU beds, such an approach reduces the number of patients being moved into and out of the ICU, thereby reducing infection risk. This can be of particular importance for certain subsets of surgical patients, such as those undergoing transsphenoidal surgeries, who may have a higher risk of contracting COVID as a nosocomial infection and therefore have a greater need to be physically distanced from infected patients within the ICU.

Given that neurological patients may be managed in less-specialized care areas, most ICUs have embraced the tele-ICU model for intensification of attending physician oversight of the unit, particularly after hours, when the attending physician could then comanage the unit with a medical intensivist. The tele-ICU technology has also enabled specialist consultation at satellite hospitals that normally do not have neurointensivist coverage. These positive steps are likely to improve patient care delivery in the ICU in the immediate future.

The COVID crisis posed a challenge to family interactions in the ICU. During the peak of the crisis, most hospitals barred all family members from visiting patients. More recently, hospitals have opened visitation to a limited number of family members, with strictly regulated visitation hours. The inability to spend long hours with patients has added to the stress and frustration of family members. To ameliorate this problem, ICUs have implemented video interface technology to allow patients and family members to see each other and communicate. In addition, the same technology is being used for communication between caregivers and patients’ families, often with complex discussions that include goals of care. Moving forward, these video platforms will play an important role in patient-centered decision making, especially when family members are in other states or countries.

Impact on Neurosurgical Research
A significant challenge faced in neurosurgery during these unprecedented times was forced closure of most research laboratories. At Weill Cornell Medicine, nonessential personnel, including medical students, were asked to remain home, with most non—COVID-related research endeavors halted. Projects were put on hold, and summer research internships were cancelled. Remote opportunities emerged, however, and researchers and trainees found these opportunities fascinating and rapidly adapted. It is likely that this way of doing laboratory research will continue in the future.

Clinical research, also initially frozen, began moving forward at greater efficiency and took shape in novel ways during the COVID peak at Weill Cornell Medicine. With the redeployment of many members of the Weill Cornell Medicine Institutional Review Board, new methods were needed to streamline review processes. This new workflow is leading to more efficient processing of
Clinical trials. A massive increase in the number of clinical trial submissions, as new, urgent COVID-related clinical trials were created during the peak of the pandemic, also led to the impetus to derive more efficient institutional review board processes. These mechanisms will carry forward in the future to the benefit of the research community, including neurosurgical researchers. News about COVID clinical trials has helped to educate the public about clinical trial processes and the need for participation as trial subjects. Hopefully, the steep COVID-driven learning curve will translate into more robust interest in clinical trial enrollment—a challenge that has plagued clinical trials in the past. We predict that the enhanced levels of clinical trial participation will accelerate the pace of clinical research in neurosurgery and other fields.

Some creative solutions to the slowing of traditional research activities emerged during the COVID peak. At our institution, a novel “Medical Student Neurosurgery Publication Group” has been thriving since its inception in the early spring, as students began initiating simple research projects, with a goal of publishing academic papers under supervision of faculty advisors. This effort has resulted in numerous projects, ranging from literature reviews to complex patient-centered studies, in a paradigm that will continue beyond the pandemic. The conception and desire to create such a publishing group in the Department of Neurological Surgery had been present for a long time; COVID-19 provided the necessary push to both the faculty and students to actualize the idea. Such an increase in engagement and personal agency from aspiring neurosurgical trainees, born from challenging circumstances, will translate well going forward.

In general, the migration to online rather than in-person collaboration appears to be expanding creative scientific thinking. In our institution, there has been an increase in cross-disciplinary and international research collaborations as a result of the shift to online communication. The enhanced ability to work remotely online during and after the peak of the COVID pandemic has moved new collaborations along with greater speed and has enhanced the efficiency and efficacy of existing ones. Remote platforms such as Zoom have allowed research teams to continue their work and expanded communications in ways that were present but underused in the past. Two of the authors (S.C.P. and S.C.) were able to fast-track a project via remote collaboration sparked by COVID to develop an international venture that has resulted in a patent application and 2 manuscripts. It was the opinion of the research team that this form of research work can and should endure after the COVID era. Our department’s medical students, residents, and faculty are thriving in this new, streamlined environment.

**IMPACT ON NEUROSURGICAL EDUCATION**

**Challenges and Opportunities in Medical Student Education and Training**

Medical schools had to respond promptly to COVID-19 from the onset of the crisis. Our institution first removed medical students from all patient-facing educational activities and quickly transitioned them to remote learning environments. Such a transition presented its own hurdles and opportunities. For instance, preclinical classes were readily converted to an online format; most lectures were already being recorded to allow students the chance to reread them. Published data show the benefits of this mode of teaching, highlighting medical student engagement and appreciation at having a virtual resource that augments their success in achieving educational objectives. These new virtual classes are here to stay and are facilitating rapid growth of extracurricular courses among highly specialized fields, such as neurosurgery, that have historically not been well represented among core medical school curricula.

Movement to a distance learning predominance for medical student education has increased the number of neurosurgical training opportunities as both preexisting and new conferences have moved online. This newly collaborative nature of online education may likely lead to a more equitable education model for both international and U.S. aspiring neurosurgical trainees without home neurosurgery programs. Additionally, as the feasibility of distance learning in neurosurgery becomes more apparent, demand and participation of both students and faculty, for the time being, appears to be increasing. With the development of nationally collaborative projects, such as the Medical Student Neurosurgery Training Center (https://www.neurosurgerytraining.org), faculty and students of all years are volunteering to plan weekly teaching conferences and develop novel neurosurgical learning resources. To the best of our knowledge, this is an unprecedented activity in the history of neurosurgical education; aspiring neurosurgical trainees, worldwide, with a common interest (in neurosurgery) are coming together with faculty guidance to drive the creation of learning opportunities for themselves and their peers. It appears that the disruptive force of the COVID-19 pandemic has overcome the inertia of neurosurgical education and set it on an entirely new trajectory.

Patient-facing educational encounters, on the other hand, have been more difficult to adapt during the COVID-19 crisis. A survey completed by members of the medical student neurosurgery interest group at Weill Cornell Medical College showed how most responders went from having 3–5 shadowing interactions with the department to having none after COVID-19 started. Similarly, subinternships have been cancelled nationally for this year: Our department went from having 16 visiting students in 2019 to having none. In the future, innovative virtual reality technologies might help enhance remote clinical learning and skill building. Virtual reality teaching and surgical tools will now have a burgeoning role in increasing the collaborative experience in remote teleimmersive medical and neurosurgical teaching opportunities. This is particularly true for operating experience, where virtual reality simulators have already been tested in helping enhance trainee skills in various scenarios. These simulation tools can now be expanded for use with neurosurgery residents as well in this era of socially distanced clinical learning.

Telehealth has also boomed during these challenging times. During medical student clinical rotations and resident training, telehealth visits allow a modicum of trainee-patient interaction. These innovations create new opportunities for trainees during a time when direct clinical exposure in the wards, ICU, and OR is limited to preserve the safety of students, residents, and patients.
Virtual Conferencing and International Academic Discourse in Neurosurgery

One of the main consequences of COVID-19 has been the cancellation of most society meetings, conferences, and training groups. For instance, major neurosurgical events, such as the American Association of Neurological Surgeons Annual Meeting and the neurosurgery intern training camp, have been cancelled, with both transitioning to an online format. Conversion to virtual conferences has significantly lowered costs for participants and organizations. Participation at a global level has been facilitated and in many ways has become democratized. Costly international travel has long been a barrier to conference participation, but now, anyone interested has the chance to attend at minimal or no cost. Similarly, neurosurgeons struggling with the dilemmas of practice coverage and case volume/revenue needs versus the desire to attend conferences and learn may find a feasible balance. With respect to the intern training camp, modified plans will provide for an online portion to be followed by an in-person local one; each department will now be required to provide a faculty mentor for the latter. Albeit taxing, this will allow small groups of junior residents to be closely mentored by a senior neurosurgeon, potentially improving their learning experience thanks to a higher faculty-to-resident ratio.

A change to remote teleimmersive neurosurgical conferences has occurred on every scale and has amplified the collaborative experience. Our department, for example, has transitioned to an online-only Zoom-based format for weekly neurologic surgery grand rounds. This format has allowed continuous participation during the pandemic, has permitted the involvement of individuals who could not usually attend, and has minimized the inconvenience to the speaker, who no longer needs to travel to deliver the lecture. In addition, in our department and others, inexpensive recording via Zoom has allowed us to create a rich archive of teaching material. This model has been a way to adapt in the face of the new challenges posed by this social-distancing era. In the future, a hybrid in-person and remote model could be used for these meetings—speakers could meet with small groups of people after giving a live-streamed presentation.

CONCLUSIONS

The COVID-19 pandemic has affected all aspects of our society, including health care, in severe and unexpected ways. The global pandemic has posed several challenges to the status quo in neurosurgical patient care, research, and education. These challenges have led us to several realizations about the limitations and potential areas of growth in the field of neurosurgery. Importantly, we have learned that we are dependent on our hospitals’ finite resource capacity to provide our services. We are dependent on the availability of ORs, ICUs, staff, and personal protective equipment to deliver optimal care. Moreover, the intensity of the COVID-19 crisis in NYC highlighted the fact that there is little buffer room in our health care systems to handle the disruptions of a pandemic and that we are highly vulnerable to interruptions in supply chains and resources. On the other hand, the COVID pandemic has also highlighted several opportunities for potential growth and improvement in how we conduct neurosurgical research, deliver neurological teaching, and provide patient care. The important role of new technologies and innovative thinking to address health care challenges has never been clearer as the way forward into the future of neurosurgery and health care at large.

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