



## EDITORIAL

## Innovations in neurosurgical education during the COVID-19 pandemic: is it time to reexamine our neurosurgical training models?

Samuel B. Tomlinson, BA,<sup>1,2</sup> Benjamin K. Hendricks, MD,<sup>2</sup> and Aaron A. Cohen-Gadol, MD, MSc, MBA<sup>2,3</sup>

<sup>1</sup>School of Medicine and Dentistry, University of Rochester Medical Center, Rochester, New York; <sup>2</sup>*The Neurosurgical Atlas*, Indianapolis, Indiana; and <sup>3</sup>Department of Neurological Surgery, Indiana University, Indianapolis, Indiana

**E**DUCATION is a core mission of academic medical centers under all but the most unusual circumstances. There is hardly a modern precedent for the global COVID-19 pandemic. Thus, the resiliency and infrastructure of our medical education system is being tested like never before.

At the time of this writing, more than 700,000 cases of COVID-19 have been documented across a total of 177 countries.<sup>1</sup> The United States, having surpassed Italy as the country with the most confirmed cases, is preparing its already strained healthcare system for a continued surge of critically ill patients, with no end in sight. In an era in which social distancing seems the most effective measure for limiting disease transmission, medical students have been either banished from the wards or ushered into the workforce ahead of schedule. Residents outside of disease epicenters are adjusting to a new reality of virtual didactics and reduced clinical schedules, while those in New York City are charging to the front lines with limited personal protective equipment (PPE). These unrecognizable circumstances have left everyone to wonder, what is the role of medical education in a pandemic? How do we balance the imperative of social distancing with the need for hands-on training? What alternative learning modalities can be implemented?

The disruptive impact of COVID-19 on neurosurgical residency education has been nothing short of extraordinary. Most hospitals in the United States have restricted all nonessential elective surgeries and procedures in accordance with recommendations from the American College of Surgeons<sup>2</sup> and Centers for Medicare and Medicaid Services,<sup>3</sup> drastically reducing surgical opportunities for residents. Rationing of PPE has left residents at some institutions either unscrubbed on the sidelines or banned

altogether from the operating room. Many programs have restructured their call schedules to reduce their number of in-house residents, while others face the possibility of resident redeployment to a service with greater demand (e.g., trauma, intensive care). Residents in the midst of their dedicated research years grapple with institutional suspensions of critical research activities, which threaten their scientific progress. At the level of organized neurosurgery, the 2020 American Association of Neurological Surgeons (AANS) Annual Scientific Meeting was canceled for the first time since World War II, followed by postponements of the written and oral examinations administered by the American Board of Neurological Surgery.

These unfathomable circumstances require flexibility and creativity. Although there is clearly no substitute for time in the operating room, residency programs have been quick to migrate the didactic components of the training curriculum online. Web-based educational platforms have become the frontier of innovation in the era of COVID-19. Learning experiences well suited for online platforms include video teleconferencing, lectures, case conferences, and journal clubs, among many others. Resources developed by the Congress of Neurological Surgeons (CNS) and distributed through their complimentary online education program are exciting examples of the possibilities for web-based learning.<sup>4</sup> The foundation of this CNS program includes grand round webinars and live interactive Virtual Visiting Professor sessions. Case repositories from the CNS Nexus, AANS Online Case Studies, and our society journals can also be integrated into an e-learning curriculum. Neuroanatomy resources, chief among them The Rhoton Collection distributed by the AANS, are virtually endless and imperative.

The educational resource developed by the senior

author and his team, *The Neurosurgical Atlas* ([www.neurosurgicalatlas.com](http://www.neurosurgicalatlas.com)), has witnessed a dramatic (> 20%) increase in site traffic since the emergence of COVID-19. Introduced in 2016, the *Atlas* is a free, online, multimedia resource focused on operative techniques and microsurgical anatomy.<sup>5</sup> The *Atlas* has a large international subscriber base, including thousands of members (36,000 total) in disease epicenters such as China, Italy, and the United States.<sup>6</sup> The largest audience demographic (approximately 45% of visitors between 25 and 34 years old<sup>7</sup>) includes medical students and residents, whose learning is likely to be impacted by the global pandemic.

For years, the *Atlas* has aimed to develop virtual resources that can supplement, although never replace, the cognitive skill set obtained during live surgical cases. Unique resources that address this goal include a new neuroanatomy section that allows users to navigate surgical dissection images by selecting and highlighting structures of interest. The *Atlas* has also recently published and is currently expanding its collection of highly realistic 3D neuroanatomy models that can be viewed online or in a virtual reality space.<sup>8,9</sup> Anatomical models in the library currently include the skull,<sup>10</sup> cerebrovascular system,<sup>11</sup> brainstem, cavernous sinus, temporal bone,<sup>12</sup> specific surgical corridors (e.g., orbitozygomatic, supraorbital, pterional, interhemispheric), and various disease entities (e.g., olfactory groove meningioma, frontal arteriovenous malformation). Most models include built-in annotations for user reference. Survey evidence from neurosurgical residents has shown that these 3D models are preferred over conventional 2D textbook illustrations for learning complex regional anatomy, such as the temporal bone.<sup>12</sup>

Neurosurgery learners across the training spectrum can find an exciting, rich collection of web-based learning resources to supplement their training during the pandemic. However, times like this make us appreciate all that is special about operative training and highlight the mere supplementary role that these online resources can have in the residency curriculum. Perhaps the lessons learned from the COVID-19 pandemic will further invigorate researchers working to bring high-fidelity surgical simulators into the mainstream of neurosurgical education. Consider, under these circumstances, the utility of a realistic operative simulator that could be practiced on in isolation by an individual user, then cleaned, sterilized, and reset for the next learner. The widespread availability of such technology could allow for continued hands-on training for residents even under strictly enforced conditions of social distancing.

The COVID-19 pandemic has disrupted neurosurgical education to an unprecedented degree. The rapid embrace of web-based platforms by residency programs has enabled some continuation of the educational curriculum despite the incredible obstacles. We eagerly anticipate a future in which significant advances in simulation technology and virtual reality will leave us far more prepared for any similar crises on the horizon.

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## Disclosures

Dr. Cohen-Gadol is the president and founder of *The Neurosurgical Atlas*, and Mr. Tomlinson and Dr. Hendricks are contributors. The authors do not receive any financial benefit for their work with *The Neurosurgical Atlas*.

## Correspondence

Aaron A. Cohen-Gadol: [acohenmd@gmail.com](mailto:acohenmd@gmail.com).

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