Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Early Changes to Neurosurgery Resident Training During the COVID-19 Pandemic at a Large U.S. Academic Medical Center

Joshua D. Burks, Evan M. Luther, Vaidya Govindarajan, Ashish H. Shah, Allan D. Levi, Ricardo J. Komotar

- BACKGROUND: The coronavirus disease 2019 pandemic has led to sweeping changes in residency programs across the world, including cancellation of elective cases. The effects of safety measures on neurosurgical training remain unclear. To understand how neurosurgical residents have been affected, we analyzed the operative experience in the months leading up to and during the pandemic.

- METHODS: The resident and institutional case totals were tallied for a single residency program in Miami-Dade County from January 1, 2019 to June 30, 2020. A matched cohort analysis was performed before and during the pandemic to assess the effects on resident surgical training.

- RESULTS: The case totals for all levels of training were lower when restrictions were placed on elective surgeries. An average of 11 cases was logged in April 2020, a decrease from 26 cases in April 2019 (95% confidence interval, 8.7–22; P < 0.01). An average of 20 cases was logged in May 2020, a decrease from 25 cases in May 2019 (95% confidence interval, 1.2–8.8; P = 0.01). In April and May 2020, 299 (66%) and 148 (50%) fewer cases had been performed at our institution compared with April and May 2019.

- CONCLUSIONS: Operative experience was reduced for residents during the months when the performance of elective cases was restricted. Our data suggest experience in some areas of neurosurgery were more affected than were others, and residents at different levels of training were also affected differently. However, the extent of the coronavirus disease 2019 pandemic on neurosurgical training is unlikely to be understood in the short term.

INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic has had major effects on every aspect of the U.S. healthcare system. The disease outbreak has led academic medical centers across the nation to restructure residency programs to limit the exposure of residents—who serve a critical function of the workforce—while continuing to provide patient care.1,2 The spread of COVID-19 infection within neurosurgery training programs, which tend to be smaller than other specialties, would be catastrophic because any infected individual would be required to leave the workforce for a minimum of 10–14 days. Efforts to mitigate this risk have broadly focused on reducing bedside consultations to only those absolutely necessary, nonvoluntary time off, minimizing in-person handoffs, and cancelling cases. In recent domestic and international surveys of neurosurgery residents, the vast majority have reported that their surgical training had been affected.3–5

Within the department of neurological surgery at our institution, a clear benefit occurred from early strategies to reduce exposure and limit disease transmission among residents. To date, only 2 cases of COVID-19 have been documented among the trainees in our program. However, the effects of the safety measures on surgical training have remained unclear. For our institution, these measures included cancellation of nonurgent cases for 3–4 weeks beginning in late March 2020.

Four months after restructuring resident duties to meet the needs of our community, we compared the institutional operative

Key words - COVID-19 - Operative - Pandemic - Residency - Surgery - Training

Abbreviations and Acronyms

CI: Confidence interval
COVID-19: Coronavirus disease 2019
PGY: Postgraduate year

Department of Neurological Surgery, University of Miami Miller School of Medicine, Miami, Florida, USA
To whom correspondence should be addressed: Joshua D. Burks, M.D.
[E-mail: joshua.burks@jhsmiami.org]
Citation: World Neurosurg. (2020) 144:e926-e933.
https://doi.org/10.1016/j.wneu.2020.09.125
Journal homepage: www.journals.elsevier.com/world-neurosurgery
Available online: www.sciencedirect.com
1878-8750/$ - see front matter © 2020 Elsevier Inc. All rights reserved.
experience in the months leading up to the pandemic and during the pandemic to better understand which areas of surgical training had been affected the most. Miami-Dade County was at the epicenter of a second spike in COVID-19 cases, which, in turn, led to another moratorium on elective surgeries in late July 2020. This latest reduction in surgical volume has underscored the need to better understand how resident training is being affected to allow training programs to provide measures to alleviate the effects on training from 1 year to the next. The results from the present analysis should serve to inform other surgical subspecialty training programs of the anticipated differences in operative experience as a result of COVID-19.

METHODS

Program Restructuring During COVID-19 Pandemic

Our service covers 5 hospitals, with most resident training occurring at the university and county hospitals. The main county hospital is divided into 3 subservices: cranial surgery, spine surgery, and trauma neurosurgery. The university hospital is a combination of all subspecialties covered by a separate team. The teams change rotations every 4 months. In March 2020, these services were consolidated to minimize the number of residents in the hospital at any given time. The 3 subservices at the main hospital were merged into 1 covering service, with residents performing rounds on their individual services only as needed. Likewise, the daily round and covering team at the university hospital was reduced by one half. The COVID-19 coverage responsibilities were as follows: the in-house or on-call junior resident performed the rounds with the covering postgraduate year (PGY)-6 or PGY-7 resident at their respective hospitals. The junior and senior residents then proceeded to the operating room for the day’s cases, with the junior resident breaking as necessary to perform consultations and respond to calls from the intensive care unit and other floors. The standard intensive care unit responsibilities for junior residents also included minor procedures such as central catheter or intracranial pressure monitor placement and tracheostomy.

For larger censuses or busier operative days, additional junior and senior residents were called in. Residents off-service or performing elective rotations were to act as “reserves” if needed. Adhering to this schedule, 1 of 3 residents per class was exempt from clinical duty each week. Adhering to this schedule, 1 of 3 residents per class was exempt from clinical duty each week. The resident coverage during the COVID-19 pandemic is shown in Figure 1. Additionally, all handoffs, conferences, and didactics were performed by telephone or video conferences.

Standard precautions were taken within the hospital as have been reported previously, including minimizing face-to-face patient interactions to those absolutely necessary to enable performance of clinical examinations. The residents were supplied with the recommended personal protective equipment, and the wearing of an N-95 facemask and eye protection were mandatory at all
times for residents while in the hospital. Cases performed after March 18, 2020 and before April 27, 2020 were performed only on an emergency or urgent basis. Urgency was assessed by a dedicated operating room departmental committee, as described by Eichberg et al. Cases deemed urgent were so judged on the basis of progressive disability or an unacceptable risk to the patient.

**Analysis**

Within the neurosurgery residency program, the case numbers are prospectively recorded using the Accreditation Council for Graduate Medical Education Case Log System. All procedures are logged at the discretion of the resident for purposes of accreditation and personal records both. We obtained resident case logs for our institution from January 1, 2019 to June 30, 2020. The case numbers were tallied by month and resident PGY. Given the substantial growth of the department with the addition of new faculty during the past 2 years, only the case data from the year before the pandemic were used for the matched comparison. The institutional review board approved the collection of data for the present study (approval number, 20200632).

The resident case totals were then matched for comparison by PGY level, month, and rotation to account for differences in the divisions of in-house call and floor-related work among the junior and senior residents and the seasonal fluctuations in hospital admissions and caseloads. The case numbers for residents on dedicated elective time and residents rotating off-service were not included in the present analysis.

The institutional case totals were obtained from prospectively collected departmental records. The recorded data included surgery date, procedure name, Current Procedural Terminology codes, and the resident, fellow, and attending surgeons present during the case. The case classifications were broadly adapted from the Accreditation Council for Graduate Medical Education Case Log System minimum requirement categories. The institutional case totals were also matched by month and year for comparison.

**Statistical Analysis**

Continuous variables are reported as the mean with 95% confidence intervals (CIs), unless otherwise specified. Categorical variables are reported as frequencies. Between group analyses were conducted using paired difference testing, and bivariate correlations were assessed. Independent samples t tests were used for comparisons of the mean values in unpaired samples. A P value of ≤ 0.05 was considered statistically significant. All statistical analyses were performed using SPSS, version 24 (IBM Corp., Armonk, New York, USA).

**RESULTS**

A total of 24 resident case logs were reviewed for the study period. No lapse was found in resident coverage for the months reviewed. During the study period, the highest case totals were noted for the PGY-6 and PGY-7 residents. Lower case totals for all levels of training were recorded for all rotations in April 2020. With the exception of the spine service PGY-7 residents, all residents had also recorded fewer cases for May 2020. The resident case totals are shown in Figure 2.

In the matched analysis, an average of 15 fewer cases (58%) had been logged in April 2020 (95% CI, 8.7–22; P < 0.01). An average of 5 fewer cases (20%) had been logged in May 2020 (95% CI, 1.2–8.8; P = 0.01). No significant differences were found in the number of cases logged during the other months studied (Table 1).

A comparison of the institutional case numbers showed a significant reduction in the overall case numbers for April and May 2020 compared with the same months in 2019 (mean difference, −21; 95% CI, −36 to −5.5; P = 0.01; and mean difference, −10; 95% CI, −20 to −1.0; P = 0.03, respectively). A total of 102 cases of thoracic or lumbar laminectomy with or without instrumentation had been performed in April 2019 (23% of all monthly cases), with only 22 performed in April 2020 (14% of all monthly cases), a 78% reduction. In April 2019, 19 functional/epilepsy cases had been performed (4% of all monthly cases), with 2 performed in April 2020 (1% of all monthly cases), an 89% reduction. A total of 118 neuroendovascular cases had been performed in April 2019 (26% of all monthly cases), with 33 performed in April 2020 (21% of all monthly cases), a 72% reduction. The institutional case numbers stratified by month are listed in Table 2.

The mean number of residents participating per case is listed in Table 3. From May 2019 to May 2020, a significant increase was found in resident participation per case (range, 1.5–1.8; mean difference, 0.3; 95% CI, 0.1–0.4; P < 0.01). Similarly, from June 2019 to June 2020, a significant increase had occurred in resident participation per case (range, 1.4–1.6; mean difference, 0.2; 95% CI, 0.1–0.4; P < 0.01).

**DISCUSSION**

**COVID-19 Pandemic’ Effect on Operative Experience**

Sweeping changes have occurred across the healthcare system in response to the COVID-19 pandemic. Hospitals have responded by expanding intensive care units, drafting new teams to treat affected patients, and cancelling elective clinic visits. Surgical caseloads around the world have been drastically reduced secondary to the cancellation of elective cases. Consequently, residency programs have restructured coverage to meet the needs of their hospitals and communities. The full extent of the effects of the COVID-19 pandemic on U.S. training programs will not be known for some time. After the initial quarantine restrictions were lifted in the state of Florida in late April 2020, Miami-Dade County saw a remarkable second spike in COVID-19 cases, with >1 in 4 individuals tested having a positive result as of July 15, 2020. These included 12 of 30 members (40%) of the Miami Marlins professional baseball team, who had tested positive at the end of July. In contrast, major league baseball had previously reported a 0.05% positive rate across the rest of the league. This unfortunate resurgence of COVID-19 cases across the region again led to cancellations of most elective cases at our institution.

It is unclear what the long-term effects of the current pandemic will be on residency training, especially the effects on surgical training, which relies heavily on operative experience. Previous investigators have proposed thoughtful suggestions for supplementing resident training. However, our present experience in Miami has offered a unique opportunity for an interim assessment. By analyzing resident case logs and institutional...
Figure 2. (A) Average cases logged stratified by resident postgraduate year (PGY) from January to June in 2019 and 2020. During the study period, the highest case totals were noted for PGY-6 and PGY-7 residents. Lower case totals for all levels of training were noted for all rotations in April 2020. (B) With the exception of spine service PGY-7 residents, all residents had also recorded fewer cases for May 2020.
case numbers at our high-volume centers before and during the COVID-19 pandemic, the effects from the present study offer an early look at how neurosurgery resident operative experience has been affected.

Across our program, we found a reduction in case numbers during the months of moratorium on elective cases. Residents on operative rotations had performed an average of 58% fewer cases in April 2020 than in April 2019 and an average of 20% fewer cases in May 2020 compared with May 2019. In June 2020, the residents had actually performed, on average, slightly more cases than their counterparts on the same rotation in 2019.

This reduction in resident cases logged corresponded to the overall reduction in case volume across the institution. In April 2020, 299 fewer cases (66%) had been performed compared with April 2019 and 148 fewer cases (50%) in May 2020. As the resident case logs had increased in June 2020 compared with May 2020, so too had the total number of institutional cases during June 2020 by 51 cases (113%). During the moratorium, the most affected case types were those involving thoracic or lumbar laminectomy and instrumentation, epilepsy surgery, deep brain stimulation, and endovascular surgery. Other investigators have similarly noted a disproportionate cancellation of complex spine cases and major effects on neurointerventional cases. Brain tumor cases constituted a greater proportion of the cases performed during those months, although also reduced in number compared with the number performed in 2019. Other investigators have also provided details regarding the case numbers at the height of the pandemic. However, the present report is the first, to the best of our knowledge, of the relative changes in surgical case numbers during the COVID-19 pandemic by case type.

In response to the decrease in the number of operative cases that began in late March 2020, new measures were adopted to increase resident operative experience. In the early days of the COVID-19 pandemic, our institution had limited resident coverage of cases to avoid unnecessary exposure to the virus. However, the availability and turnaround time of the COVID-19 polymerase chain reaction testing rapidly improved in the subsequent months, allowing more residents to scrub into cases once a negative COVID-19 test result had been obtained. This is apparent from the increase in the mean number of residents per case during May 2020 from 1.5 to 1.8, indicating that more cases had had ≥2 residents in each case than in the months before May 2020. A similar increase was seen in the number of residents per case in June 2020 despite an overall increase in the number of cases for that month compared with June 2019.

### Table 1. Comparison of Mean Total Resident Case Numbers Stratified by Month

| Year | Mean Difference (95% CI) | P Value |
|------|-------------------------|---------|
| Month | 2019 | 2020 | Variation (%) | January | 28 | 30 | +7.1 | 2.4 (−5.7 to 10) | 0.54 |
|      |      |      |                | February | 25 | 28 | +12 | 2.9 (−4.0 to 9.9) | 0.38 |
|      |      |      |                | March | 24 | 23 | −4.2 | 0.7 (−3.0 to 4.4) | 0.69 |
|      |      |      |                | April | 26 | 11 | −58 | 15 (8.7 to 22) | < 0.01 |
|      |      |      |                | May | 25 | 20 | −20 | 5.0 (1.2 to 8.8) | 0.01 |
|      |      |      |                | June | 24 | 25 | +4.2 | 0.8 (−5.2 to 6.8) | 0.78 |

Cl, confidence interval.

Measures to Blunt the COVID-19 Pandemic’s Effects on Training

The resident and institution case numbers were significantly lower during cancellation of elective cases. Other quarantine measures did not overly affect case experience, as reflected by the stable case numbers during the other months from January to the end of June 2020. The low resident infection rate was an important part of dampening the effect on operative experience. At our institution, a positive test result requires a 2-week quarantine, followed by repeat testing before a resident is allowed to return to work. Because only 2 residents have tested positive during the pandemic to date, the residents in our program were only off-service on their scheduled “off-weeks,” which, in total, resulted in no more than 2–3 weeks out of the operating room for any given resident.

Differences in the daily responsibilities among residents should be considered, because this is the greatest source of between-resident variability in case numbers. Junior residents tend to carry most of the in-house call in U.S programs and, consequently, will perform fewer operations than their senior counterparts who are unburdened by post-call days off. Additionally, senior level residents will typically be involved in more complex cases that would be performed on an elective basis. Hence, the effects of a pandemic would be expected to have a lesser impact on the operative experience of a PGY-1 resident than a PGY-7 resident.

We emphasize that the effect on operative experience seen in the present study had resulted from several weeks of elective case cancellations and that resident training would be affected at a much greater magnitude if cancellations were to last through the autumn. Thus, we began to allow double scrubbing of urgent cases (resident and resident or resident and fellow). In contrast, other institutions have reported the loss of resident participation in operations during the pandemic. There are advantages and disadvantages to higher numbers of residents participating in each case. More opportunities can result for fellow to resident and resident to resident teaching, which can sometimes be counteracted by less hands-on time during the case. Under these circumstances, an operating room culture that supports education and teamwork is critical.

Training adjuncts have long been understood to have an important role in the development of technical skill among neurosurgery residents. We found cases involving thoracic and lumbar spinal instrumentation, open vascular microsurgery, endovascular neurosurgery, and functional and epilepsy surgery to be the most affected by the COVID-19 restrictions. This would suggest these should be areas of focus for learning within the laboratory setting. Our institution has successfully hosted surgical courses for residents during the pandemic by limiting the number of people in the laboratory to maintain adequate spacing between workstations. Others have highlighted obstacles to continuing wet-bench research with social distancing requirements, which requires creative solutions.
### Table 2. Comparison of Institution Case Numbers Stratified by Case Type*

| Month          | Year (\(n\), %) | Mean Difference (95% CI) | \(P\) Value |
|----------------|------------------|--------------------------|-------------|
|                | 2019             | 2020                     |             |
| January        | 429              | 440                      | 0.50 (−7.0 to 6.0) | 0.87 |
| Cervical spine | 58 (14)          | 29 (6)                   |             |
| Thoracic/lumbar spine | 101 (24)       | 120 (27)                 |             |
| Intradural spine | 3 (1)            | 7 (2)                   |             |
| Peripheral nerve | 5 (1)            | 3 (1)                   |             |
| Endovascular diagnostic | 58 (14)       | 70 (18)                 |             |
| Endovascular treatment | 33 (8)         | 30 (7)                  |             |
| Cranial tumor  | 89 (21)          | 103 (23)                 |             |
| Vascular open  | 19 (4)           | 19 (4)                   |             |
| Trauma\(\d\)  | 11 (2)           | 12 (3)                   |             |
| Functional/epilepsy | 11 (2)       | 14 (3)                   |             |
| CSF diversion  | 17 (4)           | 18 (4)                   |             |
| Cranioplasty   | 6 (1)            | 2 (1)                    |             |
| Craniotomy pain| 3 (1)            | 2 (1)                    |             |
| Other          | 14 (3)           | 6 (1)                    |             |
| February       | 392              | 415                      | 1.4 (−7.5 to 4.9) | 0.65 |
| Cervical spine | 35 (9)           | 49 (12)                  |             |
| Thoracic/lumbar spine | 107 (27)       | 90 (22)                  |             |
| Intradural spine | 6 (1)           | 2 (1)                    |             |
| Peripheral nerve | 6 (2)            | 4 (1)                    |             |
| Endovascular diagnostic | 75 (20)       | 65 (18)                  |             |
| Endovascular treatment | 24 (6)         | 38 (9)                   |             |
| Cranial tumor  | 66 (17)          | 91 (22)                  |             |
| Vascular open  | 20 (5)           | 18 (4)                   |             |
| Trauma\(\d\)  | 17 (4)           | 9 (2)                    |             |
| Functional/epilepsy | 16 (4)       | 21 (5)                   |             |
| CSF diversion  | 15 (4)           | 15 (4)                   |             |
| Cranioplasty   | 4 (1)            | 2 (1)                    |             |
| Craniotomy pain| 0 (0)            | 2 (1)                    |             |
| Other          | 0 (0)            | 4 (1)                    |             |
| March          | 381              | 366                      | −1.1 (−6.9 to 4.8) | 0.70 |
| Cervical spine | 53 (14)          | 55 (15)                  |             |
| Thoracic/lumbar spine | 76 (20)       | 61 (17)                  |             |

**Continues**

### Table 2. Continued

| Month          | Year (\(n\), %) | Mean Difference (95% CI) | \(P\) Value |
|----------------|------------------|--------------------------|-------------|
|                | 2019             | 2020                     |             |
| Intradural spine | 2 (1)           | 3 (1)                    |             |
| Peripheral nerve | 6 (2)            | 6 (2)                    |             |
| Endovascular diagnostic | 52 (14)       | 58 (16)                  |             |
| Endovascular treatment | 42 (11)       | 16 (4)                   |             |
| Cranial tumor  | 77 (20)          | 95 (26)                  |             |
| Vascular open  | 17 (4)           | 23 (6)                   |             |
| Trauma\(\d\)  | 20 (5)           | 18 (5)                   |             |
| Functional/epilepsy | 10 (3)       | 10 (3)                   |             |
| CSF diversion  | 18 (5)           | 13 (4)                   |             |
| Cranioplasty   | 2 (1)            | 2 (1)                    |             |
| Craniotomy pain| 2 (1)            | 0 (0)                    |             |
| Other          | 4 (1)            | 6 (2)                    |             |
| April          | 451              | 152                      | −21 (−36 to −5.5) | 0.01 |
| Cervical spine | 35 (8)           | 25 (16)                  |             |
| Thoracic/lumbar spine | 102 (23)       | 22 (14)                  |             |
| Intradural spine | 3 (1)           | 2 (1)                    |             |
| Peripheral nerve | 10 (2)           | 5 (3)                    |             |
| Endovascular diagnostic | 83 (18)       | 20 (13)                  |             |
| Endovascular treatment | 35 (8)         | 13 (8)                   |             |
| Cranial tumor  | 105 (23)         | 39 (26)                  |             |
| Vascular open  | 14 (3)           | 3 (2)                    |             |
| Trauma\(\d\)  | 17 (4)           | 5 (3)                    |             |
| Functional/epilepsy | 19 (4)       | 21 (5)                   |             |
| CSF diversion  | 12 (3)           | 8 (5)                    |             |
| Cranioplasty   | 6 (1)            | 0 (0)                    |             |
| Craniotomy pain| 5 (1)            | 5 (3)                    |             |
| Other          | 1 (1)            | 1 (1)                    |             |
| May            | 429              | 281                      | −10 (−20 to −1.0) | 0.03 |
| Cervical spine | 43 (10)          | 32 (11)                  |             |
| Thoracic/lumbar spine | 107 (25)      | 62 (22)                  |             |
| Intradural spine | 0 (0)           | 0 (0)                    |             |
| Peripheral nerve | 4 (1)            | 3 (1)                    |             |
| Endovascular diagnostic | 80 (19)       | 37 (13)                  |             |

CSF, cerebrospinal fluid.
*Complete case information was not available for 13 cases (0.3%).
\(\d\)Decompressive craniotomy/craniectomy or infectious abscess.

**Continues**
Our faculty have hosted regular online teaching symposia, resulting in new learning opportunities.23 Regular didactics have been continued without interruption throughout the pandemic, including weekly grand rounds and daily resident conferences via video chat, as described by other programs.24,25 We have additionally hosted virtual subinternship experiences for interested medical students, who face unprecedented obstacles to entering the field of neurosurgery. Most medical students surveyed across the United States reported that neurosurgical conferences had been cancelled at their institution, and most third-year medical students reported their neurosurgery subinternship had been delayed or cancelled.26 The effects of the COVID-19 pandemic on the 202 neurosurgical match remains to be seen.

**Study Limitations**

The principle limitations of the present study resulted from a number of inherent differences between the residents included. Characteristics such as motivation, skill level, and attending preference are difficult to quantify yet could contribute to a resident completing more or fewer cases. Even in the absence of a global pandemic, neurological training requires constant evaluation to ensure the highest quality education for the trainees.27 Ultimately, multi-institutional analyses after the pandemic will be required to highlight the operative and training disparities that occurred during the pandemic, and long-term follow-up of trainees’ experiences will be warranted in the future, as other investigators have noted.28 Such analyses will prove valuable in reassessing the requirements for accreditation.29 However, as Kemp et al.30 recently suggested, greater collaboration among departments nationally and internationally might be an unexpected “silver lining” of the pandemic. Other innovations such as improved laboratory and virtual models could be a valuable addition to resident surgical training even after the pandemic has subsided.

Our findings have affirmed that the pandemic’s impact on training is intimately connected to the resumption of surgical activity in each hospital, which is dependent on national, local, and institutional protocols. Our institution’s experience will be different from that of other residency programs in other cities or countries;31 however, it might serve as an example for others who wish to ensure the highest possible level of training for neurosurgery residents during the pandemic. At the time of writing, several states, including Wisconsin, Utah, and Oklahoma, are still seeing an increase in new case numbers,32 with no clear end in sight.

**CONCLUSIONS**

In our study of a single academic training center, operative experience was reduced for neurosurgery residents when the performance of elective cases was restricted. The results from our analysis suggest that experience in some areas of neurosurgery have been more affected than have others. However, the effect of
the COVID-19 pandemic on neurosurgical training is unlikely to be understood in full until a long-term, multicenter study becomes feasible.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Joshua D. Burks: Conceptualization, Formal analysis, Data curation, Writing - original draft. Evan M. Luther: Data curation, Writing - review & editing. Vaidya Govindarajan: Data curation, Investigation. Allan D. Levi: Writing - review & editing. Ricardo J. Komotar: Writing - review & editing, Visualization, Project administration.

ACKNOWLEDGMENTS

The authors thank Ingrid Menendez for her tireless dedication as Residency Program Coordinator.

REFERENCES

1. Juprasert JM, Gray KD, Moore MD, et al. Restructuring of a general surgery residency program in an epicenter of the coronavirus disease 2019 pandemic: lessons from New York City. JAMA Surg. 2020;155:870-875.
2. Nassar AH, Zern NK, McIntyre LK, et al. Emergency restructuring of a general surgery residency program during the coronavirus disease 2019 pandemic: the University of Washington experience. JAMA Surg. 2020;155:564-577.
3. Alhaj AK, Al-Sadi T, Mohammad F, Alabri S. Neurosurgery residents’ perspective on COVID-19: knowledge, readiness, and impact of this pandemic. World Neurosurg. 2020;138:2848-2858.
4. Zota C, Raffa G, Somma T, et al. COVID-19 and neurosurgical training and education: an Italian perspective. Acta Neurochir (Wien). 2020;162:1789-1794.
5. Pelargos PE, Chakraborty A, Zhao YD, Smith ZA, Dunif SF, Bauer AM. An evaluation of neurosurgical resident education and sentiment during the coronavirus disease 2019 pandemic: a North American survey. World Neurosurg. 2020;140:e361-e365.
6. Vargo E, Ali M, Henry F, et al. Cleveland Clinic Akron general urology residency program’s COVID-19 experience. Urology. 2020;140:1-3.
7. 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. 2020;99:E83-E85.
8. Vincent JL, Creteur J. Ethical aspects of the wake of SARS-COVID-19: considerations regarding safety, feasibility and impact on clinical management. Acta Anaesthesiol Scand. 2020;64:367-373.
9. COVIDSurg Collaborative. Elective surgery can be cancelled due to the COVID-19 pandemic: global predictive modelling to inform surgical recovery plans. Br J Surg. 2020;107:1440-1449.
10. Bernucci C, Brembilla C, Veicsetchi P. Effects of the COVID-19 outbreak in Northern Italy: perspectives from the Bergamo neurosurgery department. World Neurosurg. 2020;137:485-486.e1.
11. Kaye K, Paprottka F, Escudero R, et al. Elective, non-urgent procedures and aesthetic surgery in the wake of SARS-COVID-19: considerations regarding safety, feasibility and impact on clinical management. Aesthet Plast Surg. 2020;44:1013-1042.
12. Kogan M, Klein SE, Hannon CP, Nolte MT. Orthopaedic education during the COVID-19 pandemic. J Am Acad Orthop Surg. 2020;28:e65-e66.
13. Gimenez CA. Statement from Miami-Dade County Mayor Carlos A. Gimenez on the recent limits put on restaurants, gyms, and other businesses. Available at: miamidade.gov. Accessed July 24, 2020.
14. Keppner T. Baseball’s Nightmare: One Team, 14 Infections. New York, NY: The New York Times; 2020. Available at: https://www.nytimes.com/2020/07/17/sports/baseball/marlins-game-cancelled.html?searchResultPosition=15. Accessed October 15, 2020.
15. Louis CT, Zeineddine HA, Esquenazi Y. Challenges of neurosurgery education during the coronavirus disease 2019 (COVID-19) pandemic: A U.S. perspective. World Neurosurg. 2020;135:e345-347.
16. Lau X, Bauer DE, Kohler A, Uçkay I, Farshad M. Disproportionate case reduction after ban of elective surgeries during the SARS-CoV-2 pandemic. Clin Spine Surg. 2020;33:244-246.
17. Rothrock RJ, Maragos GA, Schuerrer AJ, et al. By the numbers analysis of effect of COVID-19 on a neurological residency at the epicenter. World Neurosurg. 2020;142:e439-e439.
18. Jean WC, Irons IV, Sack KD, Feldbaum DR, Sedy HR. The impact of COVID-19 on neurosurgeons and the strategy for triaging non-emergent operations: a global neurosurgical study. Acta Neurochir (Wien). 2020;162:1229-1240.
19. Gordon WE, Gienapp AJ, Jones M, Michael LM, Kilimo P. An analysis of the on-call clinical experience of a junior neurological resident. Neurosurg. 2019;85:290-297.
20. Khalfallah AM, Jimenez AE, Lee RP, et al. Impact of COVID-19 on an academic neurosurgery department: The Johns Hopkins experience. World Neurosurg. 2020;139:e877-e884.
21. Yadav VR, Patil R, Rater S, Kher Y, Iqbal M. Microneurosurgical skills training. J Neurol Surg A Cent Eur Neurosurg. 2016;77:148-154.
22. Clark VE. Editorial: impact of COVID-19 on neurosurgery resident research training [e-pub ahead of print]. J Neurosurg. 2020. https://doi.org/10.3171/2020.4.JNS20104, accessed October 15, 2020.
23. Ivan M. Anatomy guided microneurosurgery for intrinsic cerebral lesions. Miami Global Brain Tumor Symposium. Available at: https://www.youtube.com/playlist?list=PLLNwVBR0ZEdZddibFsVp4aQdDqBvIbkO. Accessed October 15, 2020.