

Unexpected Decrease in Shunt Surgeries Performed during the Shelter-in-Place Period of the COVID-19 Pandemic

Nealen Laxpati, MD, PhD ¹✉*

David P. Bray, MD^{2*}

Jennifer Wheelus, NP³§

Kimberly Hamilton, MD³§

William Boydston, MD, PhD³§

Andrew Reisner, MD³§

Michael Sawvel, DO³§

Joshua J. Chern, MD, PhD³§

¹Department of Neurosurgery, Emory University School of Medicine, Atlanta, Georgia, United States of America;
²Pediatric Neurosurgery Associates, Children's Healthcare of Atlanta, Atlanta, Georgia, United States of America

*Nealen Laxpati and David P. Bray contributed equally to this work.

Correspondence:

Joshua J. Chern, MD, PhD,
Pediatric Neurosurgery Associates,
Children's Healthcare of Atlanta,
5455 Meridian Mark Rd NE,
Suite 540,
Atlanta, GA 30342, USA.
Email: Joshua.Chern@choa.org

Received, August 16, 2020.

Accepted, November 11, 2020.

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BACKGROUND: It is expected that the incidence of cerebrospinal fluid (CSF) shunt malfunctions would remain unchanged during the shelter-in-place period related to the COVID-19 pandemic.

OBJECTIVE: To examine the number of shunt surgeries performed in a single institution during this time interval in comparison to equivalent periods in past years.

METHODS: The numbers of elective and emergent/urgent shunt surgeries performed at a single institution were queried for a 28-d period starting on the third Monday of March, between years 2015 and 2020. These were further stratified by how they presented as well as the type of surgery performed.

RESULTS: During the 28-d period of interest, in the years between 2015 and 2020, there was a steady increase in the number of shunt surgeries performed, with a maximum of 64 shunt surgeries performed in 2019. Of these, approximately 50% presented in urgent fashion in any given year. In the 4-wk period starting March 16, 2020, a total of 32 shunt surgeries were performed, with 15 of those cases presenting from the outpatient setting in emergent/urgent fashion. For the surgeries performed, there was a statistically significant decrease in the number of revision shunt surgeries performed.

CONCLUSION: During the 2020 COVID-19 pandemic, there was an unexpected decrease in the number of shunt surgeries performed, and particularly in the number of revision surgeries performed. This suggests that an environmental factor related to the pandemic is altering the presentation rate of shunt malfunctions.

KEY WORDS: Shunt, Hydrocephalus, COVID-19

Operative Neurosurgery 0:1–8, 2021

DOI: 10.1093/ons/opaa461

The malfunction of cerebrospinal fluid (CSF) shunts has been a long-standing problem, and consequently, there has been a significant volume of research devoted to the topic. The majority of studies have focused on the patient, surgeon, and surgery-related factors that modulate failure frequency. The most significant contributors to shunt failure have proven to be patient-related factors, such as the etiology of the hydrocephalus and age at shunting.¹ Surgery-related factors (ie, the use of surgical adjuncts and implanted hardware) and environmental factors (ie, computer tablet use and air travel) have also been studied with somewhat less clear results.^{2,3}

Perhaps the least studied and understood component to shunt malfunction centers around the caregivers of patients with shunts. Caregivers are the ultimate first responders, and it is their suspicion of shunt malfunctions that trigger the subsequent cascade of events leading to surgical intervention. There have been studies on how he/she obtains information, their general perception of the care-delivery system, and the manner in which they secure care for their loved ones.^{4–6}

During the “shelter-in-place” period related to COVID-19 pandemic, there was an expected negative perception on the safety of presenting to medical facilities.^{7,8} Shunt malfunctions are usually an urgent problem, with a somewhat unpredictable course, and a life-threatening endpoint. We anticipated that patients with shunt malfunction would meet the threshold

ABBREVIATIONS: ANOVA, analysis of variance; VAD, ventricular access device

by caregivers for evaluation and continue to present to the hospital at prepandemic rates. Herein, we compare a year-to-year pattern of shunt surgeries in our hospital for a 4-wk period annually between mid-March and mid-April and report an unexpected decrease in emergent and urgent shunt surgeries compared to prior years.

METHODS

Period of Interest and Definitions

In response to the COVID-19 pandemic, after a 2-wk period of preparations, starting on March 16, 2020, all elective surgeries were cancelled at our tertiary pediatric hospital, which serves a major metropolitan area. In addition, the overall hospital census was significantly decreased, and several units, including several of our intensive care units, were closed because of the decreased number of patients. This closely coincided with the announcement of a state of emergency in a major metropolitan city in the state on March 15, 2020—which banned public gatherings of more than 250 people⁹—as well as the governor closing all K-12 and postsecondary schools on March 16, 2020.¹⁰ A formal shelter in place for the state was ordered on March 23, 2020. As a consequence of these actions by the city, state, and hospital, significant reduction of medical and surgical clinical volume occurred, which coincided with a decrease and plateauing in the rate of new cases being diagnosed.¹¹ At the time of writing of this manuscript, this lockdown period is scheduled to continue until at least May 1, 2020.

The period of interest for this study was defined as a 28-d period starting on the third Monday in March (eg, between March 16 and April 12, 2020). Historical data for shunt-related surgeries from the same 28-d period after the third Monday in March were gathered from 2015 to 2019. For the 5-yr period, the same 5 board-certified pediatric neurosurgeons and 1 additional board-certified neurosurgeon joining in 2018, together with 6 pediatric neurosurgery fellows, had served this patient population without significant changes in the practice pattern or hospital environment.

Shunt-related surgeries included the insertion and revision of ventriculoperitoneal shunts, ventriculoatrial shunts, subdural/cyst shunts, lumboperitoneal shunts, and ventricular access devices (VAD). Also recorded were episodes of shunt infection requiring removal of the shunt system, as well as endoscopic third ventriculostomies. We did not include external ventricular drain placements. Details of the patient presentation, surgical indication, and surgical intervention were gathered from the medical record.

Shunt surgeries were categorized as “outpatient urgent” if patients presented through the emergency department (ED) or were directly admitted from the clinic with plan for operative intervention within 24 h of presentation. “Outpatient elective” shunt surgeries were also seen in clinic but were scheduled on elective basis and did not require intervention within 24 h. “Inpatient urgent” shunt surgeries applied to patients who were already admitted prior to the period of interest, such as shunt malfunctions during a prolonged hospital stay. “Inpatient elective” shunt surgeries included shunt re-insertion after successful shunt infection treatment, tumor resection, VAD conversion to permanent shunt.

Shunt surgeries were also categorized by the nature of the surgery. “New” surgeries included VAD conversion to permanent shunts and shunts placed for newly diagnosed hydrocephalus. “Revisions” were defined as surgical exploration and replacement of one or all shunt

components, externalization, and placement of a new shunt system after successful shunt infection therapy. “Removals” included removal of infected shunt systems and subdural shunts.

Data Collection and Analysis

Starting in 2009, various EPIC applications were adopted through the hospital system, including EPIC ASAP (emergency department application), OpTime (surgical application), EpicCare Inpatient (universal hospital system), EpicCare Ambulatory (outpatient medical record application), and ADT (inpatient and outpatient admission-discharge-transfer application). Data fields for this study were imported from these applications into a single administrative database and exported as a spreadsheet (Microsoft Excel). Institutional review board (IRB) approval was obtained (IRB 14-080). Given the use of existing records and data and lack of personal patient identifiers in this study, further patient consent was not required or sought.

The period of 2015 to 2020 was polled, and all surgeries from March and April were collected for each year. This was compared with the medical record for all surgical procedures performed during this period. Shunt surgeries were identified from these data, and the medical chart was reviewed to appropriately classify the patient. These data were then uploaded into MATLAB R2012b (The MathWorks, Natick, Massachusetts) for analysis.

The third Monday in March was identified in each year as day 0, and all cases were divided into 1 of 4-wk-long periods. A 1-way analysis of variance (ANOVA) was performed across these weeks, followed by a multiple comparison's test when the ANOVA reached statistical significance. Figures were generated in MATLAB with the resulting data.

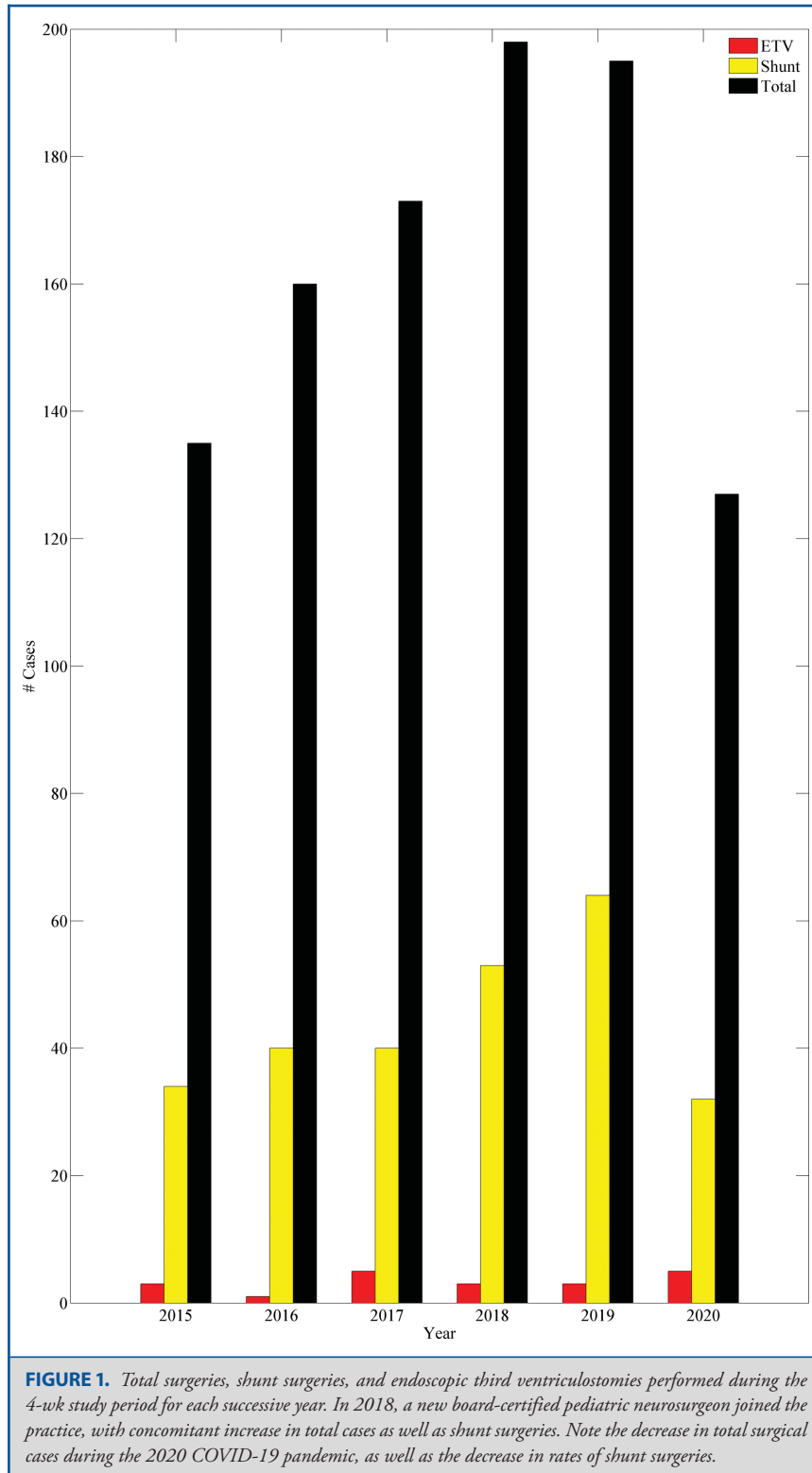
RESULTS

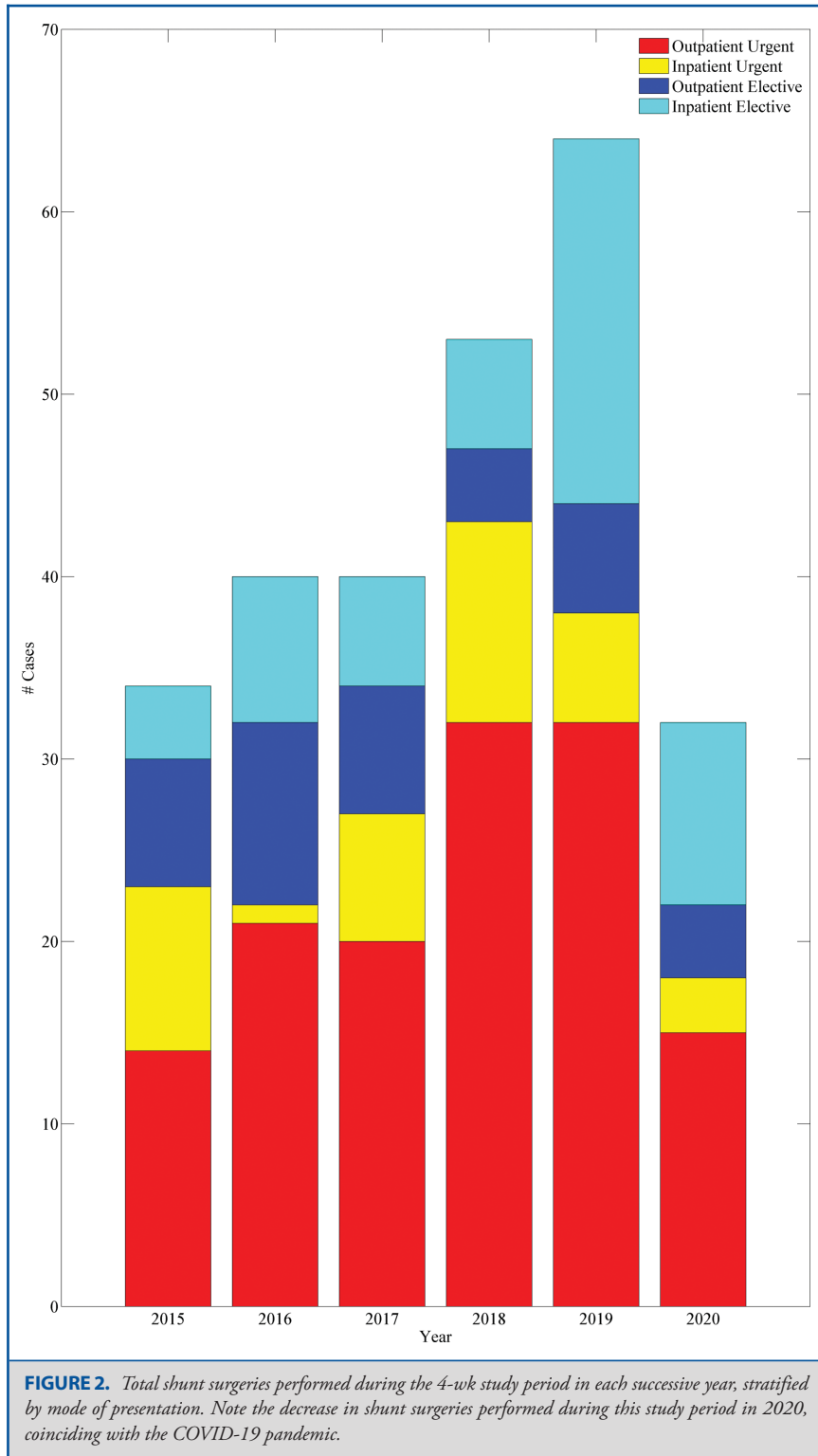
Shunt Surgery Volume by Year and Presentation

A total of 263 total shunt surgeries were identified in the 4-wk period defined between 2015 and 2020. From 2015 to 2019, there was a gradual increase in the frequency of shunt surgery during this time frame (Figure 1), with a maximum of 64 shunt surgeries performed during the study period in 2019. This increase paralleled the overall trend in total surgical cases (Figure 1). There was a largely stable rate of endoscopic third ventriculostomies during the study period across every year. In 2020, there was a clinically significant decrease in the total shunt surgeries performed as compared to prior years (Figure 1). The proportion of shunt surgeries in regard to method of presentation was largely unchanged, however, with approximately 50% of surgeries presenting in urgent fashion from outpatient settings (Figure 2).

Shunt Surgery Volume by Week

We then proceeded to stratify the rate of shunt surgeries by week. We noted that when averaged over the 4-wk study period, there was a statistically significant decrease in the rate of shunt surgeries performed between 2019 and 2020 ($P < .05$). We then specifically compared the total surgeries performed with the subgroup that presented in an urgent outpatient fashion (Figure 3). Similar to the total cases, a pronounced clinically significant decrease in the number of surgical cases was noted in 2020 as compared to prior study years. However, this did not





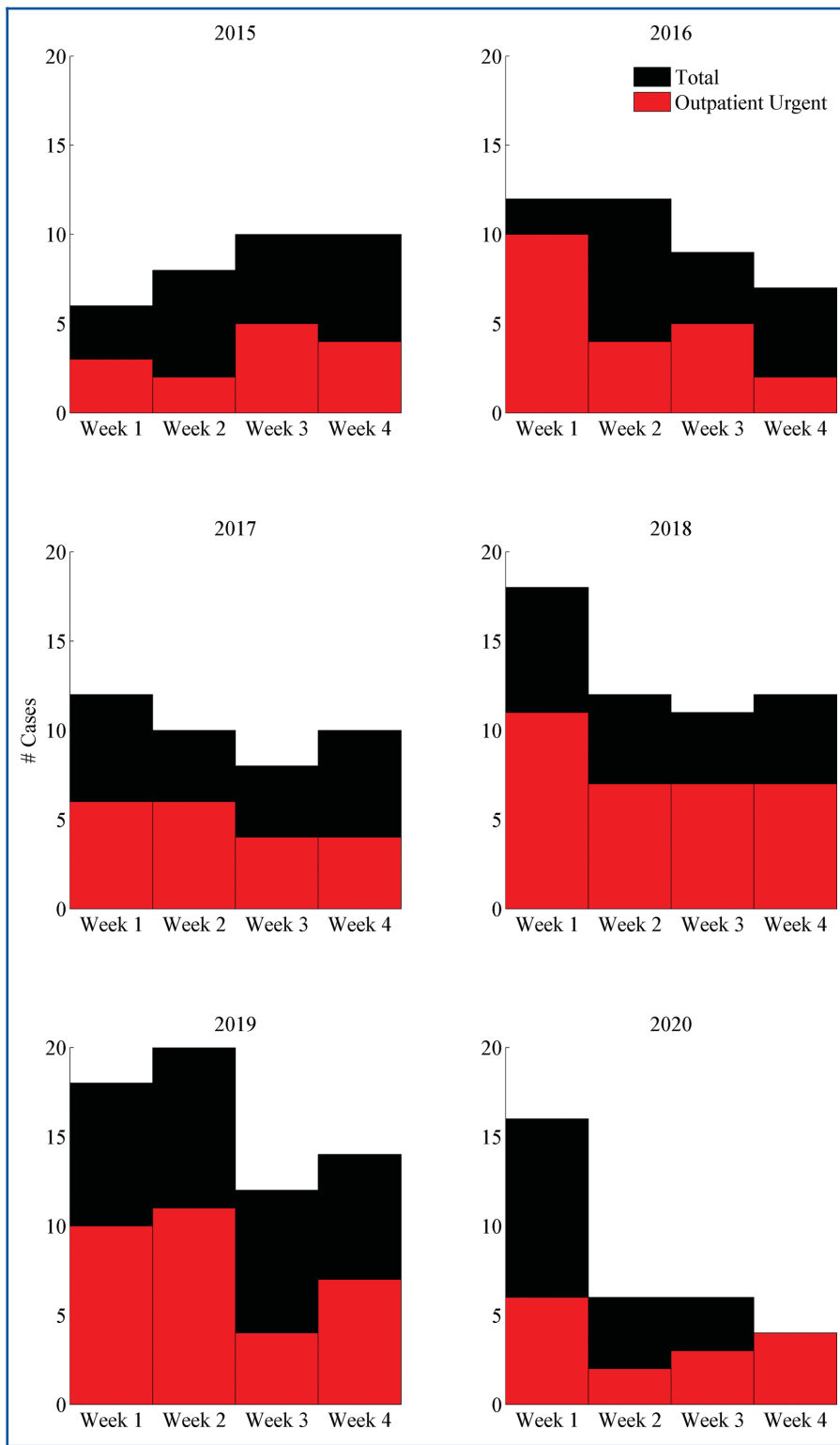


FIGURE 3. Total shunt surgeries performed for each week of the 4-wk study period, compared to the number of these cases that presented in an outpatient and urgent fashion.

reach the threshold for statistical significance. This decline also appeared to be progressive throughout the 4-wk period (Figure 3; 2020). Indeed, all urgent presentations remained decreased as compared to prior years, particularly the most recent.

Shunt Surgery Volume by Type of Surgery

Given this decrease in total shunt surgeries performed during the study period in 2020 as compared to prior years, we then explored what type of shunt surgery was being undertaken (Figure 4). Although the rate of new shunts inserted and shunts removed remained largely unchanged, there was a statistically significant ($P < .05$) decrease in the total shunt revisions performed in 2020, as compared to 2018 and 2019.

DISCUSSION

Our Results

In 2 prior studies based on ED visits made at our institution between 2010 and 2014, we had observed that there were approximately 750 annual ED visits made by shunt patients. These 750 visits resulted in approximately 100 surgeries.^{12,13} Therefore, we would expect 8 to 10 urgent shunt surgeries presenting in emergent fashion from the outpatient setting for any given 4-wk period. Similarly, we have documented that 55% of our shunt surgery patients were admitted through ED.¹⁴ During the shelter-at-home period, we noted a decrease in the volume of outpatient calls and ED consultations regarding concerns for shunt malfunctions in our patient population. This prompted our evaluation of historical and current shunt surgery case volumes.

Our results suggest that there has been a statistically significant decrease in total shunt surgeries performed during the 4-wk lockdown period associated with the COVID-19 pandemic. This was associated with an equal decrease in both urgent and nonurgent cases, with a relatively stable proportion of ~50% of shunt surgery patient arriving through the ED or admitted for urgent surgery. There was also a statistically significant decrease in the number of revisions performed during the study period in 2020 as compared to prior years. This suggests that environmental factors affected by the pandemic lockdown have played a role in the reduced rate of shunt malfunction.

Implications

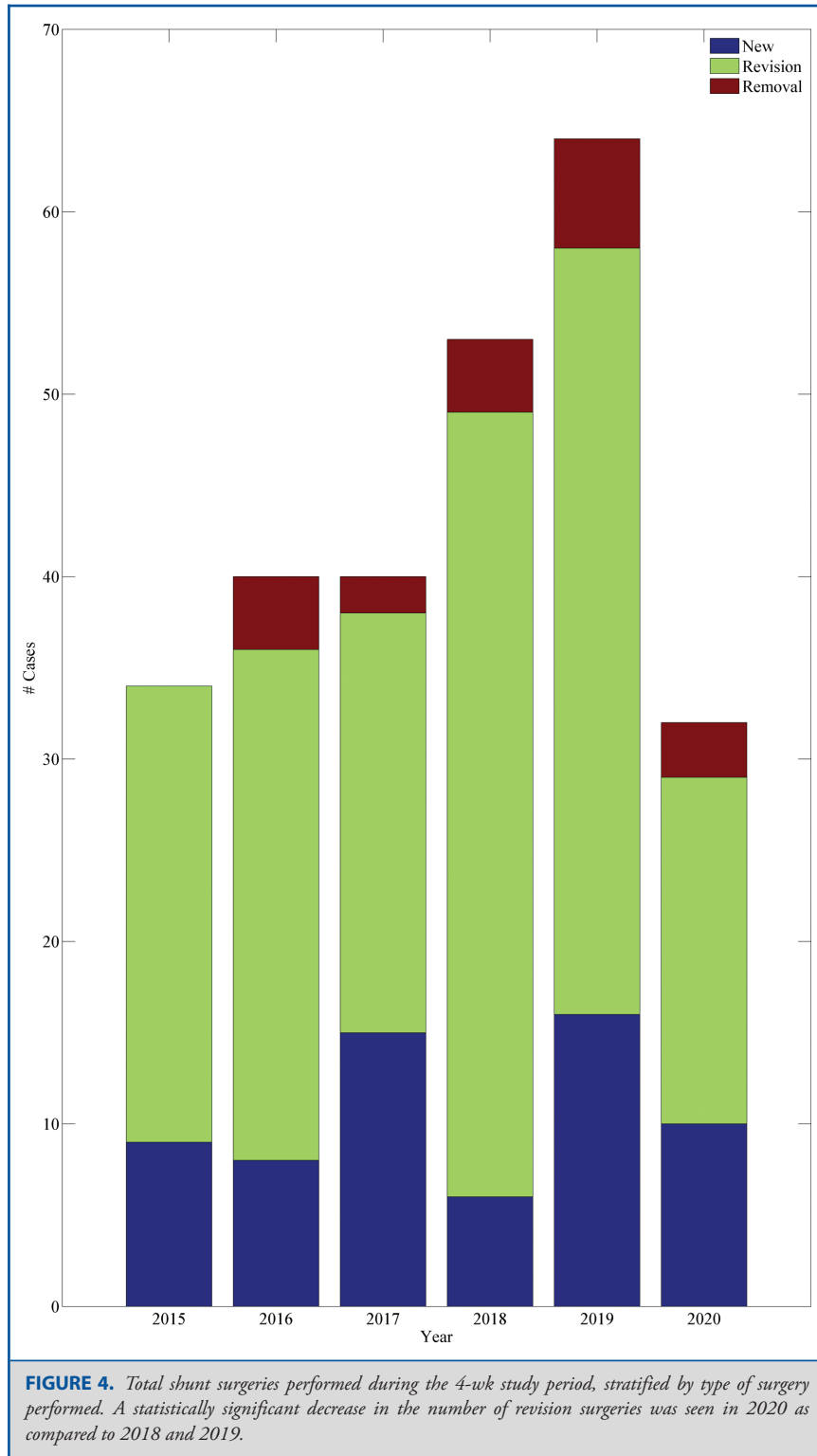
First and foremost, it is possible that our observation is simply a statistical anomaly. As time progresses, additional data will be collected to further support or refute our current observation, particularly when we look at the same study period over future years postpandemic. Indeed, we may also find a sharp increase in the rate of revision shunt surgeries as restrictions start to be lifted, implying that these cases were simply delayed. At the same time, we continue to receive information from the state health departments regarding any nontraumatic death in the pediatric population and have not noted a significant increase in possible shunt-related deaths as of the time of this publication.

If our results hold, however, there are interesting ramifications of the noted decrease in the rate of shunt revision surgeries. Presumably, this rate should be steady and independent of the current pandemic, instead dependent upon the total number of shunts in the population. Although there is growing evidence that SARS-COV-2 can infect the nervous system with potentially profound results, there is no current evidence that suggests that SARS-COV-2 has effects on the rate of CSF production or hydrocephalus.¹⁵ Furthermore, one would expect existing hydrocephalus and newly diagnosed hydrocephalus to be affected equally, and there was no statistically significant decrease seen in the rate of presentation for new hydrocephalus. Consequently, it appears that the decreased rate of shunt revisions was a result of a factor indirectly influenced by the pandemic that did not affect new shunts.

The results of this study call into question general preconceptions regarding the etiology of shunt malfunctions. The multitude of work on shunt malfunction focuses on the shunt hardware interaction with the intraventricular anatomy and CSF. However, we would not expect a pandemic to affect these intrinsic patient properties. Instead, the pandemic has led to significant changes in lifestyle and activity and implies that these environmental aspects play a major role in rates of shunt malfunction and need for revision. These environmental factors could include exposure to other children (school, daycare, and potential sick contacts), physical activity (physical education class, after school sports, and recess), stress, and sleep deprivation. Whether they play a role in the actual malfunction or serve as a mechanism to produce symptoms (eg, headache and tiredness) that may mimic signs of shunt malfunction remains to be seen. It is also quite possible that a proportion of the shunt revisions normally performed are not as time sensitive as previously believed or perhaps even wholly unnecessary. Patients present for evaluation, in part, because their concern overcomes their threshold for action. Experienced caregivers of shunted patients would need to be sufficiently concerned about their charges to overcome their fear of the pandemic, likely a higher bar than prior to the pandemic. One can imagine that although the current circumstances are deterring that population from presenting for clinical evaluation and surgical intervention, those caregivers without experience—ie, new hydrocephalus—would continue to have a low threshold secondary to the novelty of the symptoms and subsequently present at similar rates as prepandemic, as our results demonstrate.

CONCLUSION

During the 2020 COVID-19 pandemic, we noted an unexpected statistically significant decrease in the rate of shunt surgeries during a 4-wk period in March and April. Comparing this to previous years confirmed the decrease in shunt surgeries, with a noticeable decrease in the number of shunt revisions performed despite similar proportions of urgent and elective cases. It remains to be seen whether or not this trend continues or



merely represents a delay in presentation, but if true, it suggests that environmental factors may play a greater role in presentation for shunt surgery than previously understood and that a significant proportion of shunt surgeries may not be as time sensitive, or indeed necessary, to prevent morbid outcome. Further investigation, likely multi-institutional, will be required to better understand the implications of this study.

Funding

This study did not receive any funding or financial support.

Disclosures

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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