Neurosurgical Forum

LETTERS TO THE EDITOR

Spreading depolarizations in chronic subdural hematoma

TO THE EDITOR: We read with great interest Mohammad et al.'s¹ report on the occurrence of cortical spreading depolarization (SD) in patients who underwent surgery for chronic subdural hematoma (cSDH) (Mohammad LM, Abbas M, Shuttleworth CW, et al. Spreading depolarization may represent a novel mechanism for delayed fluctuating neurological deficit after chronic subdural hematoma evacuation. *J Neurosurg*. Published online March 27, 2020. doi:10.3171/2020.1.JNS192914). Delayed neurological deterioration is indeed frequent in cSDH and can be frustrating to manage. When the symptoms are transient, many patients are given a presumptive diagnosis of transient ischemic attack (TIA) or epilepsy in spite of a negative workup. A mounting body of evidence, however, shows that other processes might be at play.^{2–5}

In a previous study, we demonstrated that many patients with a negative workup (including multiple EEGs and MR images) had better discharge dispositions and lower mortality, yet worse response to antiepileptic drugs than patients with EEG-proven epilepsy.⁵ To allow prospective identification and study of these patients, we developed a semiology-based diagnostic score named NESIS (non-epileptic, stereotypical, and intermittent symptoms). It appears from both our series and the previous case reports that aphasia, as well as other prolonged, negative symptoms, are consistently experienced in this subgroup. Further analysis of our data suggests NESIS occurred in 15% of patients admitted for cSDH—an incidence similar to that of SDs in Mohammad's trial. Although SD had already been proposed as the pathophysiological basis of NESIS,^{5,6} Mohammad's group is the first to convincingly demonstrate its occurrence in the cSDH population.

Together, these findings have significant clinical implications that should orient future research, as follows.

1. Can patients with SDs be identified noninvasively? As necessary as electrocorticography was in Mohammad's study, invasive monitoring cannot realistically be used in all cSDH cases encountered in routine clinical practice. If the NESIS score is validated to reliably predict the occurrence of SDs, a clinical assessment might be all that is needed. If not, alternative approaches, such as near-infrared spectroscopy,⁷ diffuse correlation

spectroscopy,⁸ or even transcranial Doppler⁴ should be investigated.

2. Do SDs need to be treated? Although patients with NESIS were shown to have a better prognosis than those with epilepsy,⁵ patients with SDs still had a worse outcome than patients without.¹ SDs can be both benign (e.g., in migraine) or malignant (e.g., delayed cerebral ischemia in subarachnoid hemorrhage). Their exact prognosis in cSDH needs to be further studied. Can they have long-term consequences, or do they just trigger investigations and delay hospital discharge? Is there a prognostic difference between symptomatic SDs or asymptomatic SDs?
3. How should SDs be treated in the cSDH population? Many drugs have been proven effective against SDs, including ketamine, topiramate, lamotrigine, and propranolol.⁹ Topiramate and ketamine are the most studied and represent interesting candidates because they should protect patients from both SDs and seizures. Topiramate is being formally tested in the GENESIS (generation of evidence on the etiology and management of NESIS) trial.⁶ If the suspicion for seizure is low, propranolol could also represent a better-tolerated alternative.

The demonstration of SDs in patients with cSDH opens up a new avenue to improve outcomes in this frail population. It further shows how important it is to analyze our patients' symptoms with a critical eye, because not everyone with a new neurological symptom has a TIA and needs antiplatelet medication!

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Response

We thank Drs. Iorio-Morin and Levesque for their comment on our article regarding the incidence of SDs after cSDH evacuation. We agree that it is very plausible that the group of patients classified with their NESIS score may be largely detecting the clinical correlates of SD. We considered attempting to calculate this score. However, because it is a fairly detailed score we were unable to retrospectively extract these data from our cohort.

The questions that the authors posit provide an excellent framework for the most important next steps suggested by both studies. As of yet, SD cannot be reliably detected noninvasively; however, such efforts are rapidly developing. It is true also that even if SD-directed therapy in cSDH is effective, it is possible that the effect is primarily achieved through speeding clinical recovery and avoiding unnecessary workup rather than in preventing lesion development. This is consistent with the model of the deleterious effects of SD being largely dependent on the metabolic state of the underlying tissue.¹ The SD itself is a similar physiological event across the spectrum—however, in the so-called benign condition of migraine there is adequate metabolic substrate for the tissue to respond without tissue damage. cSDH may represent an intermediate state between migraine and severe brain injury, and even subtle effects on the brain could potentially affect cognitive outcomes. It is certainly plausible that “asymptomatic” SD could affect cognitive and neuropsychological recovery and that the gross clinical correlates of hemiparesis or aphasia are only the tip of the iceberg. This question is certainly worth further study.

We agree that the question of the optimal agent to test is relevant, particularly in this frail population. We have previously demonstrated the efficacy of ketamine in severely injured patients,² but this is not an ideal agent in this elderly population. Preliminary data suggest that the similar *N*-methyl-D-aspartate-receptor antagonist memantine has preclinical efficacy against SD³ as well as preliminary clinical efficacy in acute brain injury.⁴ Topiramate certainly may be a reasonable candidate and we look forward to the results of the authors’ study. Preclinical models using both topiramate and propranolol have demonstrated a relatively long latency to effect (many weeks)⁵ and so these drugs have not been widely explored clinically for acute intervention.

Finally, we agree with the authors’ concluding statement that better-targeted treatments are needed for this very common problem.

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The minipterional craniotomy: beyond the keyhole concept

TO THE EDITOR: We have read with great attention the article by Martínez-Pérez et al.¹ (Martínez-Pérez R, Albonette-Felicio T, Hardesty DA, Prevedello DM. Comparative anatomical analysis between the minipterional and supraorbital approaches. *J Neurosurg*. Published on-

line March 13, 2020. doi:10.3171/2019.12.JNS193196). We would like to congratulate the authors. It is indeed a very interesting paper, and we agree with most of the authors' statements.^{2,3}

Since its first description, the minipterional craniotomy (MiniPTC) has become one of the most used approaches in cranial neurosurgery. It reduces tissue trauma, bone flap size, and surgical time, and it improves cosmetic results while maintaining surgical area and angular exposure.⁴ Since then, our and other groups have used this technique to operate on anterior and posterior circulation aneurysms, sphenoidal and petroclival meningiomas, pituitary adenomas, and other lesions in or around the circle of Willis. This technique has been used to decompress the optic canal, drill posterior and anterior clinoid processes, peel the middle fossa, and remove the petrous apex.^{5,6}

The MiniPTC has been progressively compared with other surgical approaches, including mini-orbitozygomatic and supraorbital keyhole. However, we disagree with the authors on one point: we think it is a mistake to confound the concept behind the MiniPTC with that of the so-called "keyhole" concept.^{7,8}

The MiniPTC concept is different from other minimally invasive techniques' rationales that are based on the so-called keyhole concept. The keyhole concept is based on the principle that the deeper exposure is greater than the size of the craniotomy. However, small openings do not necessarily offer similar surgical exposures to those provided by conventional techniques and, additionally, may compromise the surgical exposure. Previous studies have demonstrated that the exposure provided by the MiniPTC technique is similar anatomically and surgically to that offered by the conventional pterional technique. In addition, clinical studies have demonstrated similar results between the MiniPTC and conventional pterional techniques, whereas functional and aesthetic outcomes are better with the MiniPTC technique. We believe the MiniPTC represents the best balance between surgical exposure and the size of craniotomy. Therefore, Martínez-Pérez and colleagues have confirmed our thoughts and have once more demonstrated the MiniPTC anatomical superiority in comparison with other minimally invasive techniques that are based on the classic keyhole concept.^{9,10}

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Response

We thank Rabelo et al. for their interest in our research and their kind feedback on our article. As noted in their letter, the minipterional (MPT) approach has been commended as one of the most versatile minimally invasive approaches to the anterior and middle cranial fossae.¹ Indeed, the MPT approach has been proved to be suitable for performing most delicate skull base maneuvers, including the removal of the anterior clinoid process^{2,3} or drilling the petrous apex to expand the access to the posterior cranial fossa.³

By reducing the size of the craniotomy and the soft-tissue disruption it is possible to obtain better cosmetic outcomes, without precluding the exposure of key neurovascular structures in the anterior circulation.¹ Nevertheless, just simply reducing the size of the opening should never be considered valid if it comes at the expense of reduced maneuverability. In the MPT approach, the superior temporal line was cleverly chosen as the superior limit of the craniotomy. This landmark ensures coverage of the skull defect with temporalis muscle and avoids any violation of the frontal sinus. Although such an exposure protects the frontal lobe, it also reduces the benefits of using the subfrontal

route. Hence, the sylvian corridor becomes essential in the MPT approach to access deeper structures.⁴ Similarly, the use of the extradural corridor, as proposed by the Chilean group, dramatically improves the surgeon's comfort and further increases the indications of the MPT craniotomy.^{5,6} The interdural dissection allows the surgeon to untether and mobilize the temporal lobe, enabling delicate microsurgical maneuvers through the pretemporal corridor along the middle fossa and upper third of the posterior fossa. Thus, although we agree that the MPT approach is superior to the traditional supraorbital approach in terms of surgical exposure of the anterior circulation key points, particularly related to the sylvian fissure, we also acknowledge that the peeling of the middle fossa exponentially increases the maneuverability along deeper structures.

Although we share the excitement with Rabelo et al. about the MPT approach, we do not recommend embracing the idea that a one-size craniotomy fits all. Conversely, we support the idea that the surgeon must select the most appropriate approach in regard to the situation. Still, we consider that the supraorbital approach has a great application for anterior fossa midline and contralateral lesions.⁷ The lateral supraorbital craniotomy described by Hernesniemi's group is a variant of the supraorbital craniotomy that offers increased maneuverability by expanding the lateral limit of the craniotomy.⁸

Expanding the supraorbital craniotomy below the superior temporal line allows the combining of the transsylvian and the subfrontal corridor to access both middle and anterior cranial fossae.^{9,10} We just tested this concept and, in the near future, will be happy to share our finding that expanding the lateral limit of the supraorbital craniotomy up to the pterion provides similar benefits to those of the MPT approach to access neurovascular landmarks along the sylvian cistern.

The MPT approach provides both excellent surgical exposure and maneuverability along the most relevant points in the anterior circulation. Nonetheless, its use should be balanced against other minimally invasive alternatives found in the neurosurgical armamentarium.

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An altered posterior question-mark incision

TO THE EDITOR: We read with great interest the article by Veldeman et al.¹ (Veldeman M, Daleiden L, Hamou H, et al. An altered posterior question-mark incision is associated with a reduced infection rate of cranioplasty after decompressive hemicraniectomy. *J Neurosurg*. Published online April 24, 2020. doi:10.3171/2020.2.JNS193335). They found that an altered question-mark incision, developed by Lyon et al.² for decompressive hemicraniectomy (DHC), would be conducive to reduce the incidence of surgical site infection (SSI) and improve the success rate of cranioplasty. According to the authors, the reason was that the modified incision characteristic of changing the lower part of the traditional reverse question-mark incision from the front of the ear to the back can avoid injury to the superficial temporal artery (STA). We appreciate the authors' contribution. We would like to extend the benefits from the altered incision and comment on the authors' statement that “the rate of wound infection after the initial decompression is low, making intergroup differences less explicit.”¹

During the operation using the traditional incision, the preservation of the STA frequently requires careful dissection, thereby taking much time. Sometimes it is difficult to avoid injury to the STA if its location is very posterior. In addition to facilitating wound healing and reducing the risk of infection, the preservation of the STA by the altered incision has the following advantages: 1) providing a primary vascular supply in case of intracranial-extracranial bypass in the future;³ 2) having a shorter incision length because of no need for curving posteriorly above the ear; 3) allowing for the incision to be hidden within the hair, whereas the traditional incision would occur out of the hair near the zygoma; 4) providing a large decompressive window; 5) avoiding damage to the temporal branch of the facial nerve;^{2,4} and 6) saving time spent on preserving

the STA and on opening the temporal muscle above the zygoma.²

The authors found that there was an absence of a significant difference in SSI rate after DHC between the classic and altered incision types, but there was a significant difference in SSI rate after cranioplasty. They explained that the lower rate of wound infection after DHC made the difference less explicit between the two types of scalp incisions. Their explanation means that there was a higher rate of SSI after cranioplasty than after DHC. What caused this difference? There was no further explanation in their study. The following factors may account for this difference: 1) the cryopreserved skull flap may have been nonviable and may have been contaminated by bacterium;^{5,6} 2) a synthetic implant for cranioplasty may elicit a material-dependent inflammatory response, called the foreign body reaction;⁷ or 3) a reopened scar tends to exhibit poor wound healing ability.

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Response

We wish to thank Drs. Lai and Ge for their interest in

our research regarding DHC and cranioplasty, and we appreciate their critical appraisal of our recently published work. We have read their reply in detail and wish to elaborate on some of the issues that were addressed.

We agree with all the advantages highlighted in their response. As the main contributors to scalp vascularization, the superficial and deep temporal arteries, if spared, allow for a better and faster wound healing as well as a better response of the immune system to potential wound contamination.

In our experience, with a large “classic” trauma flap incision, an optimal bone flap size can also be achieved. It is true that the altered incision ending behind the ear usually exposes more posterior parts of the skull in the occipital region more easily. The tradeoff is often that, depending on individual skull morphology, the exposure of temporal bone up to the floor of the middle fossa is commonly less accessible. This problem, however, is easily overcome by rongeurium somewhat more temporal bone by using a tangential perspective underneath the skin-muscle flap.

We did observe a lower primary wound infection rate after DHC when applying the altered question-mark incision. In this cohort, mainly due to the small sample size, this difference proved nonsignificant. The advantages of better vascularization of the scalp are emphasized after cranioplasty, where a nonvascularized piece of bone is implanted superficially to a surgical incision, providing the perfect environment for bacterial reproduction. Due to the larger effect size of the altered technique after cranioplasty, differences in infection rates proved significant in our cohort only after bone-flap reimplantation.

We currently prospectively collect all data concerning DHC and its complications to extend our cohort. These data will be published in the near future and we anticipated that in a larger sample, the posterior incision type will also perform better primarily after the DHC itself, before cranioplasty. Additional points of focus here will be the development of hydrocephalus, subdural/cutaneous hygromas, and sinking of the skin flap (syndrome of the trephined).

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Global health and neurosurgery training

TO THE EDITOR: We read with great delight the article by Fuller et al.¹ (Fuller AT, Barkley A, Du R, et al. Global

neurosurgery: a scoping review detailing the current state of international neurosurgical outreach. *J Neurosurg*. Published online May 8, 2020. doi:10.3171/2020.2.JNS192517). The shortage of neurosurgery care around the world is concerning, with surgery being described as a basic necessity for humankind by the *Lancet* Commission on Global Surgery.² Indeed, partnerships between high-income countries (HICs) and low- or middle-income countries (LMICs) would not only be beneficial to hospitals and patients but could also be useful as a learning experience. Concerningly, residents often report difficulty when looking for opportunities to get involved in global surgery efforts, and this has been well publicized.³ However, we argue that the implementation of international educational programs should not simply begin at the level of residency training, but should also be directed at medical students.

Despite great interest, programs do not have official relations with underserved regions that students can take advantage of. From our experience, it can be quite difficult to plan and carry out a neurosurgery elective in underserved countries, and better formal links between universities and hospitals in HICs and LMICs would provide great benefit to both the students and the host site. It is clear that if such efforts are organized properly, medical students can improve clinical skills through exposure to conditions and diseases that are unique to regions. Keen students would also have greater flexibility to pursue clinical and research interests, unconstrained by time or space, and would be of great help to residents.

However, global health is inadequately taught in medical school, and there should be greater emphasis on healthy discussions in early years. The benefit of this cannot be overstated, and keen students can show great innovation in solving global healthcare problems, as exemplified by the increasing popularity of hackathons. This will only serve to further increase interest in neurosurgery among students.

Additionally, teaching students about cultural differences and stoking genuine passion for global health can be of great benefit to the students, the hosts, and, most importantly, the patients. As the authors rightfully emphasize, there is a greater need for connections between HICs and LMICs, and such connections could cultivate interest in global health concerns, with the added benefit of exposing students to a side of neurosurgery that is seldom seen, while stressing the great demand and versatility that neurosurgery offers. It is unfortunate that the heavy commercialization of electives means that global health electives will inevitably attract students interested in tourism. However, involving students early and providing structure to an elective can generate interest and create increased competition for elective positions. This can only be done through effective communication between both sites. Done properly, such electives could generate passion for global health and could be greatly beneficial to the students, the hosts, and, most importantly, the patients.

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Response

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The COVID-19 pandemic and the inequities of the neurosurgery match

TO THE EDITOR: The coronavirus (COVID-19) pandemic has transformed the landscape of medical education. As previously introduced in the *Journal of Neurosurgery* COVID-19 collection, medical education in the field of neurosurgery has changed significantly, with reduced surgical case volumes and fewer in-person learning opportunities in an attempt to maximize hospital safety (Bambakidis NC, Tomei KL. Editorial. Impact of COVID-19 on neurosurgery resident training and education. *J Neurosurg*. 2020;133[1]:10–11).¹ As a consequence of these shifting priorities, a multitude of new challenges face medical students pursuing neurosurgery. The public health risk of travel during this time has necessitated major changes to the format of the application cycle, most prominently including the cancellation of in-person interviews and visiting subinternships. This presents obvious challenges for applicants as they try to find a residency program that fits their career goals and personality without being able to see the hospitals or meet the residents and faculty in person. Further, the COVID-19 pandemic has created a situation in which the impact of long-standing inequities in the neurosurgical match process is set to be magnified. There has been much discussion in previous years over inherent disparities in how the match process is run,^{2–4} and the ongoing pandemic will likely exacerbate these without a unified stance from all residency programs. As residents who have recently experienced the application process, we see two important topics that we ask our neurosurgical community to address in order to

allow our match process to remain fair and equitable this year.

First, we are concerned by the trend toward unofficial visits as applicants seek to evaluate programs and make themselves known in the absence of any in-person opportunities. This comes at a time when travel presents an unprecedented risk to public health.⁵ Students are facing a fundamental inner conflict between taking every opportunity to make a lasting impression on residency programs and weighing such action against the health risks and ethical dilemmas of traveling during the ongoing pandemic. This disproportionately affects students with health conditions, the economically disadvantaged, and those abiding by the social distancing and travel recommendations. Students may also have unequal opportunities to engage in unofficial visits based on geographic location, including the regional COVID-19 burden and the density of programs in various areas of the country. Also concerning is the potential for breaking state quarantine laws. Many states, including Arizona, Utah, and Massachusetts, for example, require travelers to self-quarantine for 2 weeks upon arrival. Given the time constraints of the match process, there is a very real risk that applicants may not abide by these rules, especially those traveling to multiple unofficial visits or traveling between states that have self-quarantine requirements. For the sake of student safety and public health and to prevent applicants from breaking the law, neurosurgery needs to take a strong and unified stance against hosting students for unofficial visits. Preventing these visits altogether not only creates a fair environment for this unique match cycle but also is in the best interest of everyone's safety.

The second major challenge in this year's match comes from the downstream effects of all-virtual interviews. The built-in barriers associated with in-person interviews, including the time and cost expenditures associated with travel, inherently limit the number of interviews applicants can attend. However, these barriers disappear in the setting of virtual interviews, and the natural consequence will be students accepting and attending far more interviews, a situation that presents significant risk to the integrity of the neurosurgical match process. A group of the most-qualified students will now have the opportunity to interview at significantly more programs than in previous cycles. And this group of applicants will engage interviews that would otherwise go to other applicants, resulting in many programs having their interview spots filled by applicants who are only interviewing for "insurance" against not matching. Students having virtually unlimited interview opportunities, in the setting of programs offering a fixed number of interviews, could also create a scenario of many unfilled spots. To address these critical issues, we propose two potential solutions. First, applicants could be limited to attending only 20 interviews this season. Analysis of match data has demonstrated that students ranking 20 programs have a match rate of 95%, which suggests that ranking additional programs will have minimal impact on the chances of matching.⁶ The challenge with this solution is enforcement, but applicants could be asked to sign a pledge to remain within this maximum before undertaking virtual interviews, with their integrity as collateral to ensure compliance.

However, this would require consensus from all training programs to ask this of their applicants. Alternatively, programs could increase the number of interview spots available. In many cases, this would require using only a subset of the department on each interview day and would involve substantially more time on the part of department leadership, including program directors. However, without taking some substantial action, there are significant risks to a fair and equitable neurosurgery match this year.

As a field, we need to take a unified approach to address the inequities that are certain to be exacerbated in this year's cycle. Organized neurosurgery has made an effort to meet this challenge by offering a series of webinars to help prepare students for this unique application cycle and provide consistent expectations. The burden of consistency also lies with programs, which must adopt a cohesive approach to the execution of interviews and associated match activities this year. There is no better time than now to address these disparities and create a more equitable match process for this year, as well as the years to come.

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Response

The authors raise several concerns regarding an up-

coming unprecedented interview cycle. With the ongoing COVID-19 pandemic, protecting our medical students while adhering to public health measures remains paramount. As pointed out, variances in state-based quarantine requirements, home- and visiting-institution travel restrictions, and program density create varying advantages and disadvantages. Neurosurgery as a profession was quick to realize this, and The Society of Neurological Surgeons (SNS) quickly worked to develop an unprecedented consensus creating parity among programs and applicants. All training programs agreed to not host visiting medical students. Medical students are expected to rotate for 8 weeks at their home institution. Exceptions are allowed for students without a home neurosurgery program.¹ This policy was created to ensure students receive an adequate duration of exposure to neurosurgery, while creating parity for both programs and students. Secondly, the SNS has issued a standardized evaluation form and requirement of a third letter of recommendation from its core surgical rotation to ensure students are evaluated on the same metrics. Understandably, these changes occur with the consequence that students are unable to experience a diversity of programs. Additionally, programs, unable to host students, lose the opportunity to showcase their program to potential applicants.

These missed opportunities have created a new wave of networking and educational opportunities benefiting applicants, residents, and practicing neurosurgeons. Programs have utilized conferencing technology and social media to host lecture series, meet and greets, and virtual externships. Residents, realizing the importance of exposure to programs, created a central repository, Neurosurgery MedEd, listing events.² The Congress of Neurological Surgeons hosted a national neurosurgery symposium in June, connecting programs and applicants. Although these arose in the wake of a global pandemic, they represent opportunities for the future.

However, as pointed out, rotations are only part of the equation. The Association of American Medical Colleges has recommended that all teaching institutions conduct interviews virtually.³ Though not a mandate, this recommendation should prompt the SNS to proffer an agreement between all neurosurgical programs. However, several

potential downstream effects must be considered. First, the cost of traveling to interviews is no longer a factor. In addition, travel logistics may have previously required a student to choose between two concurrent interviews. Virtual interviews are likely to be of shorter duration than in-person interviews, and without travel, it would be possible for strong applicants to interview at significantly more programs than would have previously been affordable or possible. This could potentially increase the number of both unmatched applicants and unfilled programs. Rather than adhering to an unenforceable honor system among applicants, programs could offer interviews on pre-selected dates, forcing applicants to choose. This would resemble how applicants accepted interviews previously and be easier to enforce at a national level. Finally, understanding that students will inevitably be interested in seeing programs and cities while applying, it is imperative that we as a neurosurgical community support the public health of our students and communities to not host in-person visits for applicants.

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