A New Era for Surgical Neurotherapeutics

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Surgical interventions now have the potential to outperform traditional drug treatments in the management of many different neurological disorders. For example, in epilepsy, despite the introduction of more than a dozen new anti-epileptic medications over the past two decades, the overall rates of seizure freedom are unchanged [1, 2], whereas responsive neurostimulation is now known to confer significant improvements in seizure reduction and quality of life in these same medically refractory patients [3, 4]. Thus, modern neurosurgical techniques and devices, having low morbidity and, in many cases, excellent efficacy, are increasingly seen as part of a normal spectrum of treatment that includes medications, rather than existing in a separate dimension. In this issue of *Neurotherapeutics*, an international group of expert authors describe this new era for therapies delivered via neurosurgery, in which advances in neuroscience, computational biology, and imaging are driving both the evolution of traditional strategies and the initiation of novel approaches.

Evolution of Traditional Surgeries and Novel Adjuvants

First, Enslin and colleagues [5] describe the evolution of selective dorsal rhizotomy, one of the most commonly performed operations to treat spasticity in children with cerebral palsy. Poppler and colleagues [6] then review the state of the art for four types of chronic pain amenable to surgical

treatment. Wilson and colleagues [7] next describe novel uses of nerve transfers, including nerve transfers for sensory reinnervation, nerve transfers for spinal cord injury and stroke patients, supercharge end-to-side nerve transfers, and targeted muscle reinnervation for the prevention and treatment of post-amputation neuroma pain. Switching gears to adjuvant techniques, Fernandez-Miranda and colleagues [8] provide an overview of high-definition fiber tractography, an advanced imaging technique that they developed, and have pioneered in neurosurgical planning to optimize functional outcomes in tumor surgery. Yeh and colleagues [9] then tackle the false connection problem in tractography imaging, describing topology-informed pruning (TIP), a method that automatically identifies singular tracts and eliminates them to improve fiber tracking accuracy. Continuing a computational theme, in an original research article, Vakharia and colleagues [10] describe machine learning approaches for predicting trajectories that optimize the extent of mesial temporal lobe ablations during laser interstitial thermal therapy of epilepsy. Katz and Abel [11] provide an overview of the modern use of intracranial monitoring techniques for identifying epileptic foci in medically intractable epilepsy. Addressing a field about which there is currently much buzz, Prada and colleagues [12] discuss the evolution of high-intensity focused ultrasound, providing an overview of current and future ablative applications in oncology and cerebrovascular neurology. Darrow [13] then describes the potential for low-intensity focused ultrasound, which can both excite and inhibit neural activity reversibly to deliver a range of reversible neuromodulation therapies.

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Brain–Computer Interfaces for Restoring Movement, Seizure Control, Vision, and Speech

Brain–computer interfaces span from approaches that have been FDA-approved for decades to those on the verge of clinical application. Steigerwald and colleagues [14] begin this section by describing new deep brain stimulation electrode designs to control the direction of current flow and

implications for DBS programming and improved patient outcomes. Neumann and colleagues [15] then go to the next level by providing detailed insight into factors that affect the development of intelligent, adaptive DBS that can deliver highly individualized treatment to patients with movement disorders. Along the same lines, Sisteron et al. [16] review the evolution of closed-loop brain stimulation for epilepsy, proposing an evidence-based solution for individualizing therapy that is driven by a bottom-up informatics approach. Focusing on pediatrics, Ibrahim and colleagues [17] address neuromodulatory strategies for the treatment of intractable epilepsy in children, including putative mechanisms of action and biomarkers for treatment success. Addressing vision restoration, Niketeghad and Pouratian [18] describe the historical thinking on cortical visual prosthetics, as well as the current state of the art, explaining the design of current devices that are either under development or in the clinical testing phase. Rabbani and colleagues [19] then complete this section by introducing us to the field of neural speech decoding using electrocorticography, exploring what a brain–computer interface for speech might entail.

Neurosurgical Biologics

In the single paper describing the neurosurgical application of biologics, Sudhakar and Richardson [20] describe the gene therapy field's entry into a new technological era, in which interventional-MRI-guided convection-enhanced delivery (iMRI-CED) is the gold standard for verifying accurate vector delivery in real-time. This paradigm shift has the potential to accelerate the translation of therapies for neurodegenerative disorders that require direct delivery of the therapeutic agent into the brain parenchyma.

In all, the editors believe this collection of articles reflects a remarkable moment in the history of clinical neuroscience in which existing neurosurgical therapies continue to be fine-tuned whereas novel approaches break exciting ground.

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