EDITORIAL

Interventional Neuromodulation: What Lies ahead in Psychiatry?

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Introduction

Neuromodulation dates back in psychiatry with advent of electroconvulsive therapy (ECT) around 80 years back, but in recent years several new techniques have been developed. Repetitive transcranial magnetic stimulation (rTMS), transcranial direct current stimulation (tDCS), vagal nerve stimulation (VNS), trigeminal nerve stimulation (TNS), galavanic vestibular stimulation (GVS), transcranial electrical stimulation (tES), and deep brain stimulation (DBS) are being used commonly these days. Each works in a different way, although the principle remains to effect therapeutic change through physically modifying brain activity. Their use in different clinical groups varies between techniques, as does their underlying evidence base but overall neuromodulation data in clinical trials for various psychiatric disorders are mixed, whichever technique is evaluated.[1]

Why Neuromodulation?

Psychiatric neuromodulation has seen recent surge of interest in clinical and research domains. Neuromodulation acts through different mechanisms than pharmacotherapy, offering the potential of treatment success, where medications have not offered desirable results. Identifying and targeting specific neural circuitry or functional neural networks to reduce psychiatric symptoms may offer a level of somatic focus selection/identification beyond that offered by ECT, pharmacotherapy, or most psychotherapies. Also, despite years of research, all currently available psychopharmacology depends, in one form or another, on the manipulation of neurotransmitters related to the monoamine hypothesis. This approach was successful in bringing initial treatments to market, albeit, significant numbers of patients remain symptomatic despite the best evidence-based interventions.[2]

rTMS beyond Treatment of Depression

Transcranial magnetic stimulation is a treatment approved by the Food and Drug Administration (FDA) for major depressive disorder (MDD). The FDA cleared the first TMS machine, neuronetics, in 2008 for patients with MDD who failed one adequate medication trial during the current episode. Since then given the ability of TMS to modulate neuronal firing in both excitatory and inhibitory ways in a clinically safe and noninvasive manner, interest grew in TMS as a useful tool for the treatment of a variety of neuropsychiatric illnesses. Interest has expanded into other disorders, including schizophrenia, obsessive compulsive disorder (OCD), posttraumatic stress disorder (PTSD), attention-deficit/hyperactivity disorder (ADHD), substance use disorders, and autism spectrum disorders (ASDs). The treatment using TMS has also been helpful in minimizing polypharmacy that often accompanies refractory depression and OCD and serves as an alternative, yet evidence-based, approach to treating patients who have struggled with medication side effects as well. Moving toward the future, we need to continue to build on the current evidence to develop clearly defined, standardized protocols for different neuropsychiatric conditions. Additionally, with the rapid pace at which uses for rTMS are expanding, clinicians can have a hard time keeping up with some of the newer protocols.[3]

Future of Brain Stimulation in Psychiatry

Since Cerletti's and Bini's first use of ECT in 1938, several themes have emerged in the field of brain stimulation. These include, with new technologies and even within existing technologies, gradual decreases in stimulation intensity, greater focality of treatment, increased specificity of brain stimulation targets, and greater public acceptance of therapeutic neuromodulation. The first consideration is that neuromodulation has become more and more noninvasive with passage of time with advent of techniques such as tDCS, tACS, and low frequency ultrasound pulsations. Using robots and closed loop stimulation help achieve more focal, individually tailored and quality dosage to an individual. Also, development of advanced treatment protocols including theta-burst stimulation, ultra-brief Pulse ECT, high-definition tDCS and VNS and TNS open new vistas in achieving remission and long-lasting treatment effects in various psychiatric disorders.[4]

Personalized Neuromodulation in Psychiatry

Transcranial magnetic stimulation is seen as a viable intervention to modify brain activity and alleviate psychiatric symptoms. However, these interventions are known to be only moderately reliable and the efficacy of such therapies remains to be proven for psychiatric disorders other than depression.[5]

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New opportunities are being explored to personalize TMS interventions using neuroimaging and computational modeling, aiming to optimize treatment to suit particular individuals and clinical subgroups. Using large data sets spanning various fields and characteristics of the individuals the prospect of improving the efficacy of existing TMS interventions by parsing broad diagnostic categories into biologically and clinically homogeneous biotypes has been explored of late. Biotypes can provide distinct treatment targets for optimized TMS interventions. Computational models are being used to achieve TMS personalization and efficiently establishing optimal cortical targets for distinct biotypes. Personalizing cortical stimulation targets, treatment frequencies, and intensities can improve the therapeutic efficacy of TMS and potentially establish noninvasive brain stimulation as a viable treatment for psychiatric symptoms. Two kinds of biotypes can be delineated: dimensional and categorical. A dimensional biotype characterizes a continuous relation across individuals with respect to a set of clinical, behavioral, or biological characteristics. A dimensional biotype simplifies to a pairwise association in the case that only a single pair of characteristics is considered. In general, though a dimensional biotype characterizes a spectrum across individuals in a high-dimensional space, where each dimension represents a patient characteristic. A categorical biotype characterizes a discrete subgroup of individuals that is segregated with respect to a set of clinical, behavioral, or biological characteristics from other individuals comprising a broad diagnostic category. TMS interventions can be optimized to suit categorical biotypes. For example, if a set of biotypes primarily segregates individuals based on variation in the cortical location of brain pathology, the TMS coil position can be adjusted to target the distinct pathological location associated with each biotype.[6]

If the clinical rollout of biotype-guided TMS personalization is endorsed by future research, standardized neuroimaging protocols will be required, and validated software need to be developed to accurately and reliably determine an individual's biotype. Proof-of-concept trials assessing the efficacy of biotype-based TMS over standard approved TMS intervention for depression could provide initial motivation to undertake larger trials and extend the approach to other disorders. Ultimately, the utility of implementing personalized TMS interventions in clinical setting would require a cost-benefits analysis.[7]

Conclusion

Neuromodulation remains a burgeoning field with much room for growth. Further research is needed to more definitively determine which conditions benefit from which type of therapy. Of additional importance is determining which brain regions to target with therapy as well as standardizing evidence-based treatment protocols. We believe neuromodulation has the potential to provide relief to the many patients struggling with refractory and difficult-to-treat psychiatric illnesses while minimizing long-term side effects.

References

1. Tracy DK, David AS. Clinical neuromodulation in psychiatry: the state of the art or an art in a state? BJPsych Adv 2015;21:396–404. DOI: 10.1192/APT.BP.115.014563
2. Gaynes BN, Warden D, Trivedi MH, et al. What did STAR*D teach us? Results from a large-scale, practical, clinical trial for patients with depression. Psychiatr Serv 2009;60(11):1439–1445. DOI: 10.1176/ps.2009.60.11.1439
3. Becker JE, Shultz EKB, Maley CT. Transcranial magnetic stimulation in conditions other than major depressive disorder. Child Adolesc Psychiatr Clin N Am 2019; 28:45–52. DOI: 10.1016/j.chc.2018.08.00
4. Caulfield KA, George MS. The future of brain stimulation treatments. Psychiatr Clin N Am 2018; 41: 515–533. DOI: 10.1016/j.psc.2018.05.004
5. Sarkhel S, Sinha VK, Praharaj SK. Adjunctive high-frequency right prefrontal repetitive transcranial magnetic stimulation (rTMS) was not effective in obsessive–compulsive disorder but improved secondary depression. J Anxiety Disord 2010;24:535–539. DOI: 10.1016/j.janxdis.2010.03.011
6. Cocchi L, Zalesky A. Personalized transcranial magnetic stimulation in psychiatry. Biol Psychiatry Cogn Neurosci Neuroimaging 2018; 3(9):731–741. DOI: 10.1016/j.bpsc.2018.01.008
7. Rossi S, Hallett M, Rossini PM, et al. Safety, ethical considerations, and application guidelines for the use of transcranial magnetic stimulation in clinical practice and research. Clin Neurophysiol 2009; 120:2008–2039. DOI: 10.1016/j.clinph.2009.08.016