

Influence of the brain function through the peripheral nerves

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Over the years stereotactic neurosurgeons dedicated their work to study brain function in the operating room. The access to the functioning human brain brought the obligation of taking advantage of this unique opportunity to reveal to humanity the mysteries of the brain function. This charge was well put on our shoulders by Wilder Penfield through his monumental work.^[7] Penfield's, Spiegel and Wycis^[11] studies guided by the anatomic studies of Schaltenbrand and Wahren,^[1] as well as the electrophysiologic-anatomical correlations of Talairach guided functional neurosurgery during the last century.^[13]

We enter now in an era where we can see and analyze the brain function electrically and molecularly with previously unimaginable accuracy, correlating it to exquisite anatomy of the high tesla MRI.^[3] What could be accomplished only in the operating room setting using electrophysiology, awake patient and clinical examination, can now be studied with functional magnetic resonance imaging (fMRI), positron emission tomography (PET), magneto-encephalography (MEG), computed tomography (CT) and transcranial magnetic stimulation (TMS). Most importantly, we can integrate all this information in the operating room to improve surgery and create novel surgical approaches to diseases before not treated by neurosurgeons.^[2,8]

Neuromodulation became a real possibility for a variety of diseases that hereto were not in the realm of neurosurgery. This opens up an enormous field of research and clinical possibilities. Targeted stimulation of the peripheral nerve system with the intent of modulate brain function has been practiced empirically for various ailments, however why patients improve with electrical stimulation is still poorly understood. Methodic studies and keen clinical mind are necessary to take advantage

of the therapeutic possibilities of peripheral nerve stimulation, as we enhance the understanding of brain function in the healthy and diseased states.

One of the main conduits to the brain is the trigeminal nerve. The trigeminal nerve input brings important emotional and sensory information to the brain. The cerebral integration of these input influences both, the limbic and the somatosensory system. The trigeminal nerve is accessible to surgeons superficially, it is a nerve that functional neurosurgeons are familiar with the approach for treatment of pain, and actually have modulated its input in many ways to curb attacks of trigeminal neuralgia.^[6] Therefore, if properly modulated, guided by imaging studies and carefully conducted clinical trials, the trigeminal pathway may become the conduit for therapies in the disorders of cognition, emotion and sensory system.^[4,9] This type of approach has been successfully used when taking advantage of the vagal nerve diffuse influences in the brain to treat medically refractory seizures and major depression.

Stimulation of peripheral nerves and the resulted influence in the brain can be now detected by functional imaging [Bari *et al.*, this issue], leading to better understanding and application of each of these "ports" to the brain for specific manipulation of brain function.

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For example, stimulation of the occipital nerve is being used to treat migraine and occipital neuralgia without clear understanding of the mechanisms of action and the participation of this nerve in these diseases.^[5] Stimulation of the trigeminal nerve has been used to treat refractory facial pain for years,^[12] now being investigated to treat medically resistant depression,^[9] epilepsy,^[4] post-traumatic stress disorder, attention deficit disorders, tinnitus and other applications.^[10]

This issue of *Surgical Neurology International: Stereotactic* highlights the importance of relating peripheral nerve stimulation with functional imaging to unveil possible therapeutic opportunities for the functional neurosurgeon. As exemplified by Dr. Lars Leksell when he conceptualized radiosurgery, the future is bright having the creative and methodic mind of the stereotactic neurosurgeon, once more taking advantage of the progresses in imaging to forge new surgical procedures and unheard therapies.

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