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Review Article

Peripheral Sensory Stimulation for Neurological Disorders. A Novel, Non-invasive Therapeutic Option. Review Article

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Abstract

Peripheral sensory stimulation (PSS) represents a new area of therapy for patients with neurological disorders. Grounded in strong basic science research, PSS carries potential promise in the management of multiple diseases. We reviewed the literature regarding those conditions that represent reasonable targets for treatment with PSS including stroke, Parkinson's disease, traumatic brain injury, and auto-immune, inflammatory illness. Potential mechanisms of action are discussed, and future avenues of investigation are described.

Key Words : neurological disorders; peripheral sensory stimulation; traumatic brain injury

Introduction

Over the past decade, there has been a growing interest in the field of neuromodulation including the use of peripheral sensory stimulation (PSS) in the management of a variety of neurological disorders [1-5]. Such PSS treatment is extremely attractive because it may enhance neurological recovery from a variety of prevalent conditions with essentially no risk of serious complications [3-6]. This paper summarizes the rationale and potential uses of PSS as a method of improving neurological conditions in the areas of stroke, Parkinson's disease, and other common neurological ailments.

Discussion

Stroke

Ischemic stroke impacts roughly 700,000 individuals per year in the United States resulting in significant short-term and long-term disability and tremendous financial loss [7,8]. Although the past 25 years have seen a revolution in the management of acute ischemic stroke based on the introduction of intravenous and intra-arterial thrombolytic therapy and mechanical thrombectomy, there has been little change in the therapeutic options available to patients who have suffered a completed stroke and are left with neurological deficit [9-13].

In rodent models, PSS has been shown to significantly and reproducibly improve neurological outcomes following ischemic injury [14-16]. Small clinical trials in humans have suggested that such PSS can improve recovery after stroke as well (3,4,17-24). In general, stimulation has been directed at the affected hand (contralateral to the injured hemisphere) and may be delivered using vibrational, electrical, or pneumatic input through the delivery of air puffs [4, 17-20]. Whether the duration, intensity, or frequency of treatment will impact the effectiveness of therapy remains an ongoing area of investigation [4].

The mechanism by which PSS may improve outcome after stroke has not been elucidated, although it appears that somatosensory input modulation of corticomotor excitability may be involved [25]. It has been suggested that somatosensory therapy may enhance neuronal reorganization after stroke or traumatic brain injury, possibly utilizing intact neural circuits either in the ipsilateral or contralateral hemispheres [26-34]. Alternatively, peripheral stimulation may improve regional cerebral perfusion, encouraging recruitment of pial collateral channels and recovery of under-perfused neurons [4]. Our previous work suggests that intermittent PSS using puffs of air may provide benefit in the setting of acute stroke, and improvement in CBF as measured by perfusion MR imaging suggests that recruitment of collateral supply may play at least a partial role in this process (Figure 1).

Figure 1: Example of a peripheral sensory stimulation device that uses air puffs delivered to the hand as a mechanism of stimulation. (courtesy, Neuro Glove, Inc.)

Parkinson's Disease

It is estimated that Parkinson's disease affects more than one million individuals in the United States, and the incidence of the disease appears to be increasing as the population ages [33-6]. Although symptoms can be controlled and improved using pharmacological therapy, the disease tends to be progressive and results in substantial disability and financial loss [33-6]. The motor deficits seen in patients with Parkinson's disease have been linked to abnormally synchronized neuronal activity in dopaminergic circuits [5]. In these patients, coordinated reset based on tactile feedback has been suggested as a mechanism to overcome excessive neuronal synchronization resulting in sustained "unlearning" of pathological synaptic connectivity and synchrony [37]. Perhaps based on such a "coordinated reset" mechanism, peripheral somatosensory stimulation has been shown to benefit patients with Parkinson's disease [5,37-39].

Early small clinical studies using PSS have shown dramatic and promising improvement in Parkinson's patients with long-standing and severe motor symptoms [5,37-39]. The potential to improve quality of life in a significant manner using a non-invasive alternative to medical therapy has encouraged further evaluation of this option for patients with Parkinson's, and larger clinical trials are ongoing. It is anticipated that these trials will help to elucidate the mechanisms by which PSS may benefit patients with movement disorders such as Parkinson's disease and will also help to define those patients and symptoms most amenable to such therapy.

Other Conditions

Because of the potential for enhancing neuronal "learning" through reorganization as well as the other mechanisms previously described, PSS has been suggested as a possible mechanism to help patients with other neurological conditions including post-traumatic brain injury and auto-immune, inflammatory conditions such as multiple sclerosis. [4, 40-45] Although the mechanism by which PSS may be beneficial in such instances remains unclear, it is possible that recruitment of regional collateral blood supply, enhancement of neuronal recovery, development of new neuronal connections, and local "coordinated reset mechanisms" may all play a role in these disorders as in stroke and Parkinson's Disease [46-47].

At this point, there is inadequate evidence to prove the effectiveness of PSS in these conditions, but as trials evaluating the usefulness of this technique in stroke and Parkinson's disease expand, we will learn more about the effectiveness and mechanisms by which peripheral stimulation can affect brain functioning, and potential indications for its use may expand as well. Because of the extremely low-risk nature of PSS treatment, it would be safe and straightforward to evaluate its effectiveness in such conditions.

Conclusions

The use of PSS as a neuromodulation therapy represents a novel, non-invasive, low-risk treatment option for patients with various neurological disorders. Preliminary and small clinical studies have shown promise using this technique in patients with stroke and Parkinson's disease. At this point, larger studies are underway and will hopefully answer questions of efficacy in a more rigorous fashion. Questions that remain to be addressed include the importance of the mechanism, frequency, and duration of stimulus delivery on patient outcomes. In addition, the possible usefulness of such therapy in patients with other conditions such as post-traumatic brain injury remains to be evaluated.

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