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Mini Review

Therapeutic Role of Vagal Nerve Stimulation in Cerebral Palsy: Quantitative Electroencephalographic Evidence

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Abstract

Vagal nerve stimulation (VNS) has been proposed earlier as a therapeutic intervention in patients with cerebral palsy (CP) for improvement in their seizure-profile, cognitive status and quality of life based on which CP has been included in the list of therapeutic indications for VNS. The proposal is based on dual-effect (suppression of seizures and interictal epileptiform discharges) of VNS. This brief paper presents a statistical analysis of VNS induced electroencephalographic (EEG) effects from recent studies, which supports the therapeutic role of VNS in CP.

***Keywords**: Cognitive Status; EEG-Desynchronization; Interictal Epileptiform Discharges; Quality of Life; VNS Policy*

Background

Cerebral palsy (CP) is a common childhood neurodevelopmental disorder that is associated with a significantly high comorbidity with epilepsy and cognitive impairment (CI). It has been proposed earlier that vagal nerve stimulation (VNS), an FDA approved adjunctive therapeutic technique for intractable epilepsy, can offer an effective and successful adjunctive therapy in patients with CP [1] for improvement of their seizure-profile, cognitive status and quality of life (QOL). The choice and efficacy of VNS have been based on its dual property of inducing EEG-desynchronization (that exerts a strong antiepileptic influence) and suppressant action on interictal epileptiform discharges (IEDs) that are believed to adversely affect cognition [2-5]; thus, VNS can play a significantly important role in the control of seizures and improvement of cognitive status in the patients with CP and improve their QOL. This proposal has also formed the basis for inclusion of CP in the VNS policy on its list of therapeutic indications [6]. Recent studies have also reported efficacy of VNS in patients with CP as an adjuvant therapy [7-9].

This brief paper presents evidence from statistically analyzed VNS induced EEG-changes in favor of the above mentioned dual property of VNS that underlies the basis of its proposed efficacy and success in CP.

Electroencephalographic evidence

In one study on the effect of chronic VNS on IEDs [10], the researchers observed that the average total number of IEDs during EEG and the total number of seconds in which IEDs were present decreased significantly after 5 years of stimulation from 97.3 ± 106.9 resp. 80.6 ± 86.1 to 49.4 ± 94.0 resp. 37.8 ± 65.0. Furthermore, the reduction of IEDs was greater in patients that responded to VNS (responders) as compared to those that did not (non-responders).

In another study on cortical synchronicity [11], the authors found that the responders to VNS had a significantly lower global level of synchronization than the non-responders ($p < 0.0001$). In addition, VNS ON periods were characterized by significantly lower values of synchronization in comparison with OFF periods ($p < 0.001$) and further analysis revealed that the global synchronization levels reduced significantly in delta and alpha frequency bands in the responders ($p < 0.0001$). From their findings, the authors suggest that estimation of changes of synchronization level could function as a promising tool for predicting response to VNS.

Another recent study [12] has demonstrated marked reduction of both, epileptogenic spikes (IEDs) as well as their spread areas during VNS. The study found there were 24.80 ± 35.55 and 7.20 ± 9.93 unilaterally spread spikes in the VNS OFF and ON phases, respectively ($P = 0.157$), and 35.8 ± 29.21 and 10.6 ± 13.50 bilaterally spread spikes in the VNS OFF and ON phases, respectively ($P = 0.027$). The electrocorticograms also showed that the spectral power tended to be greater in the high-frequency band during VNS ON phase in comparison to OFF phase.

Conclusion

Thus, the statistically analyzed EEG effects inducible by VNS do encourage and strongly favor the proposed therapeutically effective application of VNS in patients with CP for improvement in their seizure-profile, cognitive status and QOL.

Declarations of Interest

None.

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