

# Assessing The Autonomic Effect Of Vagal Nerve Stimulation With Low Level Lasers By Heart Rate Variability

C Machado, Y Machado, M Chinchilla, Y Machado, H Foyaca-Sibat

## Citation

C Machado, Y Machado, M Chinchilla, Y Machado, H Foyaca-Sibat. *Assessing The Autonomic Effect Of Vagal Nerve Stimulation With Low Level Lasers By Heart Rate Variability*. The Internet Journal of Neurology. 2019 Volume 21 Number 1.

DOI: [10.5580/IJN.54164](https://doi.org/10.5580/IJN.54164)

## Abstract

Vagus nerve stimulation (VNS) has been approved to treat refractory epilepsy, and for other conditions. The invasive nature of the electrical stimulus, which requires surgical implantation of electrodes around the cervical vagus nerve, is a technical limitation. The low-level laser therapy (LLLT) is actually considered a non-invasive technique, and has been increasingly used in diverse areas of medical practice. We developed a pilot study using LLLT for VNS in normal subjects, and assessing its effect on the autonomic nervous system (ANS) by the heart rate variability (HRV) methodology. Fifteen normal participants from 22 to 46 years, divided in three groups of 5 subjects each, paired in age and gender, were studied applying VNS using LLLT by lasers of different frequencies: RED Laser (in 5 subjects); VIOLET Laser (5 subjects); and RED/VIOLET Laser (5 subjects). The study included three experimental conditions: Basal record (10 minutes), VNS (10 minutes), and Post-VNS (10 minutes). The LF/HF ratio was considered, because it provides a measurement of the parasympathetic/sympathetic balance. When the RED laser was used for VNS there was a predominance of the parasympathetic activity. On the contrary, the stimulus with VIOLET laser provoked a sympathetic prevalence. Similarly, to the stimulus with the RED laser, when the RED/VIOLET laser was applied there was a predominance of the parasympathetic activity. As a conclusion, this study showed that VNS using LLLT is a non-invasive and safe method, and should be considered for future protocols to recover parasympathetic/sympathetic nervous system balance in different conditions.

## INTRODUCTION

Electrical stimulation of the cervical vagus nerve has been approved for the treatment resistant epilepsy. In Europe and the USA for over 15 years has been used to treat about 50,000 epilepsy patients.(1-4) Vagus nerve stimulation (VNS) is also an approved therapy for treatment of resistant depression, and has been investigated as a potential therapy for a wide range of conditions including heart failure, Alzheimer's disease, obesity, chronic pain, inflammation, and tinnitus.(5-13)

It is interesting that VNS has proven effective in pilot studies for the treatment of heart failure. Heart failure is a leading cause of mortality and it is estimated that 50% of people die within 5 years of diagnosis. Heart failure is characterized by decreased parasympathetic and increased sympathetic nerve activity. Therefore, if VNS can be shown to influence this autonomic balance toward parasympathetic

predominance it could provide a method to correct imbalance in heart failure patients, and in other diseases.(7, 8, 14-18)

On the other hand, the use low-level laser therapy (LLLT) is actually considered a non-invasive technique, and has been also increasingly used in diverse areas of medical practice, such as prevention of tissue death, pain relief, reduction of inflammation, regenerative medicine, traumatic brain injury, , spinal cord injury, and stroke, autism, etc.(19-25)

One factor that may hinder larger trials of VNS is the invasive nature of VNS. VNS requires surgical implantation of a bipolar electrode around the cervical vagus nerve and implantation of a generator subcutaneously in the thoracic wall. This is associated with technical and surgical complications including wound infection, cardiac arrhythmia under test stimulation and electrode malfunction [9]. In addition, side effects include hoarseness, dysphagia, cough

and pain.(3, 13, 17, 26, 27)

Given the number of conditions that VNS has the potential to benefit, a simpler, less invasive approach would enable treatment of significantly larger numbers, like the use of VNS using low level laser therapy (LLLT). Nonetheless, the studies using LLLT for VNS are scarce.(28)

In this study we investigated the effects of VNS on cardiovascular autonomic function in healthy participants by measuring heart rate variability (HRV), and using lasers of different frequencies.

### **MATERIAL AND METHODS**

Fifteen normal participants from 22 to 46 years, divided in three groups of 5 subjects each, paired in age and gender, were studied applying VNS using LLLT by lasers of different frequencies: RED Laser (in 5 subjects); VIOLET Laser (5 subjects); and RED/VIOLET Laser (5 subjects). The study included three experimental conditions: Basal record (10 minutes), VNS (10 minutes), and Post-VNS (10 minutes). HRV was assessed to evaluate the autonomic system.

LLLT was applied by a neurologist (MCA) in the neck, left side. Subjects were continuously monitored by bedside monitors (Electrocardiogram, blood pressure, and body temperature) to early diagnose any complication. Participants received LLLT administration with the Erchonia® EAL Laser (RED, VIOLET and RED/VIOLET lasers).

#### Heart rate variability

Electrocardiogram (ECG) was recorded with the MEDICID-05 (NEURONIC, S.A.) with disposable electrodes placed on the chest in positions CM2 and V5 and using a sampling frequency of 200 Hz. Filters were set for a band spectrum of 0.5-50 Hz. The ECG was recorded in every experimental session.

Bipolar ECG recordings were exported offline as ASCII files to a software tool developed by our staff written in our Lab. Accurate “R” peak automatic detections obtained with the software’s algorithms were always visually checked and properly corrected, when it was necessary, by a member of the staff. Pre-processing of RRI sequences were applied to the R-R series.

Selected processing parameters allowed the study of spectral

frequencies from 0.02 Hz to 0.4 Hz, including the very low frequency band (VLF) band from 0.023 to 0.04 Hz, the low frequency band (LF) from 0.04-0.085 Hz; the mid-frequency band (MF) from 0,085-0.15 Hz, and for the high frequency band (HF) from 0.15-0.40 Hz. Absolute and normalized (%) values were considered for each spectral band. The ratio LF/HF was also calculated for the analysis. HRV indices calculated in the time-domain were also calculated as detailed elsewhere. The methodology for ECG recording and HRV processing can be found elsewhere. (29-33)

Informed consent was obtained for all participants. The Ethical Committee of the Institute of Neurology and Neurosurgery approved according to the “World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects”.(34)

### **RESULTS**

Although all frequency and time domain parameters were calculated, for this pilot study we only considered the LF/HF variable, because it provides a measurement of the parasympathetic/sympathetic balance.(29-31) It is important to remark that we did not detect any cardiovascular complication with the use of bedside monitors.

In figure 1, the ratio LF/HF values are presented for RED, VIOLET, and RED/VIOLET lasers, considering the three experimental conditions: Basal, VNS, and Post-VNS. When the RED laser was used there was a clear predominance of the parasympathetic activity when the VNS was applied in the 5 participants, compared to the Basal experimental condition (incremented values of the LF/HF ratio). This parasympathetic prevalence was afterwards almost reduced to the basal condition values. Only in one subject the parasympathetic predominance remained in the Post-VNS experimental condition.

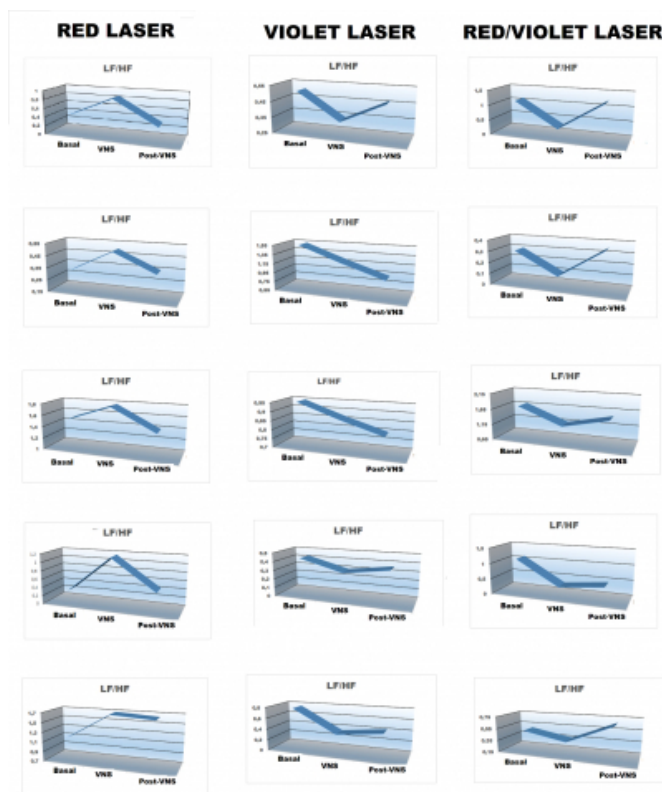
On the contrary, the stimulus with VIOLET laser provoked a sympathetic prevalence in the VNS condition (reduced values of the LF/HF ratio), which decreased to basal values in 3 participants. In 2 subject there was a progressive sympathetic predominance from Basal, to VNS, and Post-VNS experimental conditions.

Similarly, to the stimulus with the RED laser, when the RED/VIOLET laser was applied the values of the ratio LF/HF a clear predominance of the parasympathetic activity in the 5 participants, compared to the Basal experimental condition (increment values of the LF/HF ratio). This

parasympathetic prevalence was reduced almost to the basal condition values in the Post-VNS phase. Only in one subject the parasympathetic predominance remained in the Post-VNS experimental condition.

**Figure 1**

In figure 1, the ratio LF/HF values are presented for RED, VIOLET, and RED/VIOLET lasers, considering the three experimental conditions: Basal, VNS, and Post-VNS.



**DISCUSSION**

VNS is currently used to treat refractory epilepsy and is being investigated as a potential therapy for a range of conditions, including heart failure, tinnitus, obesity and Alzheimer's disease. (1-4) However, a taking in consideration the number of conditions that VNS has the potential to benefit, a simpler, less invasive method would enable treatment of significantly larger numbers, like the use of VNS using LLLT.(19, 22, 25, 35, 36)

Some authors have shown that VNS can alter cardiovascular autonomic control in healthy humans and highlights the role of the parasympathetic/sympathetic nervous system balance in mediating VNS effects.(17, 37-41)

Increased sympathetic activity and/or reduced parasympathetic nerve activity as indicated by HRV is not only a powerful and independent predictor of poor

prognosis in patients with cardio vascular disease, but also a risk factor for mortality in healthy populations. Lower vagal (HF) and higher sympathetic (LF) tone are considered to be predictors of morbidity and mortality in cardiovascular samples. (18, 42-44)

We recently demonstrated that HRV is a reliable method to assess the integrity of the neural control of the caudal brainstem centers on the hearts of patients in coma and to predict patient mortality. HRV indices showed that they can efficiently predict mortality in these patients in coma. The LF/HF index resulted reduced in non-survivors.(45, 46)

The HF component is considered to be a marker of the parasympathetic activity, meanwhile LF is a marker of sympathetic function, and relatively low of parasympathetic activity. Nonetheless, the symphato-vagal balance is accurately reflected by the fractional distribution of power across the frequency spectrum. This balance can be assessed by the relation between LF and HF components. Hence, an increase of the LF/HF ratio indicates a sympathetic predominance, meanwhile a decrement of its values signposts a parasympathetic prevalence.(29-31, 33, 45, 46)

Clancy et al. reported, using electrical stimulation of the auricular branch of the vagus nerve distributed to the skin of the ear, that VNS can increase HRV and reduce sympathetic nerve outflow, which is desirable in conditions characterized by enhanced sympathetic nerve activity, such as heart failure. These authors explained these findings on the issue that VNS could activate the caudal ventrolateral medulla to inhibit the rostral ventrolateral medulla and thus reduce sympathetic output. In addition, an activation of the dorsal motor nucleus of the vagus and the nucleus ambiguous to increase parasympathetic activity. (17) Yiloski et al., also using electrical stimulation of the auricular branch of the vagus nerve distributed to the skin of the ear, reported that VNS induced a shift in autonomic function from sympathetic preponderance towards parasympathetic predominance.(41) Some authors have emphasized that the cardiovascular system is under deep sympathetic influence in children with epilepsy, and that VNS seems to provide a substantial improvement by achieving increased parasympathetic effects in short-term therapy.(47-49) Several authors have stated that an autonomic imbalance demonstrating an increased sympathetic activity and a reduced parasympathetic activation is involved in the development and progress of epileptic seizures. Therefore, activation of the parasympathetic by VNS is a powerful tool

for the treatment of intractable epilepsy.(1, 4, 42, 50-52)

It was interesting that according to our results when the RED and RED/VIOLET lasers were used for VNS used was a clear predominance of the parasympathetic activity (incremented values of the LF/HF ratio)., meanwhile with the VIOLET laser, a predominant sympathetic function was found. These findings should be considered for future protocols of VNS using LLLT.

Of course, the limitations of this pilot study is the reduce sample of participants. Nonetheless, we have not found any publication using LLLT for VNS.

As a conclusion, this study showed that VNS using LLLT is a non-invasive and safe method, and should be considered for future protocols to recover parasympathetic/sympathetic nervous system balance.

## ACKNOWLEDGMENTS

The project was supported by Erchonia Corp., Melbourne, FL, the producers of the equipment employed in this study.

## References

1. Ekmekci H, Kaptan H. Vagal Nerve Stimulation has Robust Effects on Neuropsychiatric Assessment in Resistant Epilepsy: A Clinical Series with Clinical Experiences. *Turk Neurosurg.* 2019;29(2):213-21.
2. Falco-Walter JJ, Roehl K, Ouyang B, Balabanov A. Do certain subpopulations of adults with drug-resistant epilepsy respond better to modified ketogenic diet treatments? Evaluation based on prior resective surgery, type of epilepsy, imaging abnormalities, and vagal nerve stimulation. *Epilepsy Behav.* 2019.
3. Selner AN, Rosinski CL, Chiu RG, Rosenberg D, Chaker AN, Drammeh H, et al. Vagal Nerve Stimulation for Epilepsy in Adults: A Database Risk Analysis and Review of the Literature. *World Neurosurg.* 2019;121:e947-e53.
4. Dan B. Vagal nerve stimulation beyond epilepsy. *Dev Med Child Neurol.* 2018;60(7):634.
5. de la Torre JC. Treating cognitive impairment with transcranial low level laser therapy. *J Photochem Photobiol B.* 2017;168:149-55.
6. Nestor MS, Newburger J, Zarraga MB. Body contouring using 635-nm low level laser therapy. *Semin Cutan Med Surg.* 2013;32(1):35-40.
7. Li M, Zheng C, Kawada T, Inagaki M, Uemura K, Sugimachi M. Chronic vagal nerve stimulation exerts additional beneficial effects on the beta-blocker-treated failing heart. *J Physiol Sci.* 2019;69(2):295-303.
8. Zhou L, Filiberti A, Humphrey MB, Fleming CD, Scherlag BJ, Po SS, et al. Low-level transcutaneous vagus nerve stimulation attenuates cardiac remodelling in a rat model of heart failure with preserved ejection fraction. *Exp Physiol.* 2019;104(1):28-38.
9. Manchini MT, Antonio EL, Silva Junior JA, de Carvalho PT, Albertini R, Pereira FC, et al. Low-Level Laser Application in the Early Myocardial Infarction Stage Has No Beneficial Role in Heart Failure. *Front Physiol.* 2017;8:23.
10. Vacca A, Gai A, Govone F, Rubino E, De Martino P, Gentile S, et al. Noninvasive Vagal Nerve Stimulation in Chronic Migraine with Medication Overuse Headache. *Pain Med.* 2018;19(12):2575-7.
11. Usichenko T, Hacker H, Lotze M. Transcutaneous auricular vagal nerve stimulation (taVNS) might be a mechanism behind the analgesic effects of auricular acupuncture. *Brain Stimul.* 2017;10(6):1042-4.
12. De Icco R, Martinelli D, Bitetto V, Fresia M, Liebler E, Sandrini G, et al. Peripheral vagal nerve stimulation modulates the nociceptive withdrawal reflex in healthy subjects: A randomized, cross-over, sham-controlled study. *Cephalalgia.* 2018;38(10):1658-64.
13. Jin H, Guo J, Liu J, Lyu B, Foreman RD, Yin J, et al. Anti-inflammatory effects and mechanisms of vagal nerve stimulation combined with electroacupuncture in a rodent model of TNBS-induced colitis. *Am J Physiol Gastrointest Liver Physiol.* 2017;313(3):G192-G202.
14. Nishikawa T, Saku K, Todaka K, Kuwabara Y, Arai S, Kishi T, et al. The challenge of magnetic vagal nerve stimulation for myocardial infarction -preliminary clinical trial. *Conf Proc IEEE Eng Med Biol Soc.* 2017;2017:4321-4.
15. Ripplinger CM. From drugs to devices and back again: chemical vagal nerve stimulation for the treatment of heart failure. *Cardiovasc Res.* 2017;113(11):1270-2.
16. Wang Z, Yu L, Wang S, Huang B, Liao K, Saren G, et al. Chronic intermittent low-level transcutaneous electrical stimulation of auricular branch of vagus nerve improves left ventricular remodeling in conscious dogs with healed myocardial infarction. *Circ Heart Fail.* 2014;7(6):1014-21.
17. Clancy JA, Mary DA, Witte KK, Greenwood JP, Deuchars SA, Deuchars J. Non-invasive vagus nerve stimulation in healthy humans reduces sympathetic nerve activity. *Brain Stimul.* 2014;7(6):871-7.
18. Nolan J, Batin PD, Andrews R, Lindsay SJ, Brooksby P, Mullen M, et al. Prospective study of heart rate variability and mortality in chronic heart failure: results of the United Kingdom heart failure evaluation and assessment of risk trial (UK-heart). *Circulation.* 1998;98(15):1510-6.
19. Lo Giudice A, Nucera R, Perillo L, Paiusco A, Caccianiga G. Is Low-Level Laser Therapy an Effective Method to Alleviate Pain Induced by Active Orthodontic Alignment Archwire? A Randomized Clinical Trial. *J Evid Based Dent Pract.* 2019;19(1):71-8.
20. Lou Z, Zhang C, Gong T, Xue C, Scholp A, Jiang JJ. Wound-healing effects of 635-nm low-level laser therapy on primary human vocal fold epithelial cells: an in vitro study. *Lasers Med Sci.* 2019;34(3):547-54.
21. Hong J, Desai A, Thadani VM, Roberts DW. Efficacy and safety of corpus callosotomy after vagal nerve stimulation in patients with drug-resistant epilepsy. *J Neurosurg.* 2018;128(1):277-86.
22. Safdari R, Pouremadi N, Talebzadeh E, Mottaghi A, Amini S, Hossienzadeh A, et al. The Impacts of Low-Level Laser Therapy - A Complementary Treatment in the Management of Side Effects After Implant Surgery. *J Lasers Med Sci.* 2018;9(3):207-11.
23. Thunshelle C, Hamblin MR. Transcranial Low-Level Laser (Light) Therapy for Brain Injury. *Photomed Laser Surg.* 2016;34(12):587-98.
24. das Neves MF, Dos Reis MC, de Andrade EA, Lima FP, Nicolau RA, Arisawa EA, et al. Effects of low-level laser therapy (LLLT 808 nm) on lower limb spastic muscle activity in chronic stroke patients. *Lasers Med Sci.* 2016;31(7):1293-300.
25. Leisman G, Machado C, Machado Y, Chinchilla-Acosta M. Effects of Low-Level Laser Therapy in Autism Spectrum

- Disorder. *Adv Exp Med Biol.* 2018;1116:111-30.
26. Arimura T, Saku K, Kakino T, Nishikawa T, Tohyama T, Sakamoto T, et al. Intravenous electrical vagal nerve stimulation prior to coronary reperfusion in a canine ischemia-reperfusion model markedly reduces infarct size and prevents subsequent heart failure. *Int J Cardiol.* 2017;227:704-10.
27. Frangos E, Komisaruk BR. Access to Vagal Projections via Cutaneous Electrical Stimulation of the Neck: fMRI Evidence in Healthy Humans. *Brain Stimul.* 2017;10(1):19-27.
28. Machado C, Machado Y, Chinchilla M, Shanks S, Foyaca-Sibat H. Effect of Low Level Laser Therapy on Brain Activity Assessed by QEEG and QEEGt in Normal Subjects. *The Internet Journal of Neurology.* 2018;20(1).
29. Machado C, Estevez M, Perez-Nellar J, Schiavi A. Residual vasomotor activity assessed by heart rate variability in a brain-dead case. *BMJ Case Rep.* 2015;2015.
30. Machado C, Estevez M, Rodriguez R, Perez-Nellar J, Chinchilla M, DeFina P, et al. Zolpidem arousing effect in persistent vegetative state patients: autonomic, EEG and behavioral assessment. *Curr Pharm Des.* 2014;20(26):4185-202.
31. Machado C, Estevez M, Perez-Nellar J, Gutierrez J, Rodriguez R, Carballo M, et al. Autonomic, EEG, and behavioral arousal signs in a PVS case after Zolpidem intake. *Can J Neurol Sci.* 2011;38(2):341-4.
32. Machado C. *Brain Death: A reappraisal.*: Springer; 2007.
33. Machado C, Korein J, Aubert E, Bosch J, Alvarez MA, Rodriguez R, et al. Recognizing a mother's voice in the persistent vegetative state. *Clin EEG Neurosci.* 2007;38(3):124-6.
34. General Assembly of the World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *J Am Coll Dent.* 2014;81(3):14-8.
35. Evangelista L, De Meo B, Bernabei G, Belloni G, D'Angelo G, Vanzini M, et al. Ultra-Low-Level Laser Therapy and Acupuncture Libralux: What Is so Special? *Medicines (Basel).* 2019;6(1).
36. Effect of low level laser therapy on brain activity assessed by QEEG and QEEGt in normal subjects. *The Internet Journal of Neurology.* 2018;20(1).
37. Manati W, Pineau J, Donate Puertas R, Morel E, Quadiri T, Bui-Xuan B, et al. Vagal stimulation after acute coronary occlusion: The heart rate matters. *Cardiol J.* 2018;25(6):709-13.
38. Eren OE, Filippopoulos F, Sonmez K, Mohwald K, Straube A, Schoberl F. Non-invasive vagus nerve stimulation significantly improves quality of life in patients with persistent postural-perceptual dizziness. *J Neurol.* 2018;265(Suppl 1):63-9.
39. Petrocchi N, Piccirillo G, Fiorucci C, Moscucci F, Di Iorio C, Mastropietri F, et al. Transcranial direct current stimulation enhances soothing positive affect and vagal tone. *Neuropsychologia.* 2017;96:256-61.
40. Stavrakis S, Humphrey MB, Scherlag B, Iftikhar O, Parwani P, Abbas M, et al. Low-Level Vagus Nerve Stimulation Suppresses Post-Operative Atrial Fibrillation and Inflammation: A Randomized Study. *JACC Clin Electrophysiol.* 2017;3(9):929-38.
41. Ylikoski J, Lehtimäki J, Pirvola U, Makitie A, Aarnisalo A, Hyvarinen P, et al. Non-invasive vagus nerve stimulation reduces sympathetic preponderance in patients with tinnitus. *Acta Otolaryngol.* 2017;137(4):426-31.
42. Ellens NR, Elisevich K, Burdette DE, Patra SE. A Comparison of Vagal Nerve Stimulation and Responsive Neurostimulation for the Treatment of Medically Refractory Complex Partial Epilepsy. *Stereotact Funct Neurosurg.* 2018;96(4):259-63.
43. De Ferrari GM, Stolen C, Tuinenburg AE, Wright DJ, Brugada J, Butter C, et al. Long-term vagal stimulation for heart failure: Eighteen month results from the NEural Cardiac Therapy for Heart Failure (NECTAR-HF) trial. *Int J Cardiol.* 2017;244:229-34.
44. Annegers JF, Coan SP, Hauser WA, Leestma J. Epilepsy, vagal nerve stimulation by the NCP system, all-cause mortality, and sudden, unexpected, unexplained death. *Epilepsia.* 2000;41(5):549-53.
45. Estevez-Baez M, Machado C, Garcia-Sanchez B, Rodriguez V, Alvarez-Santana R, Leisman G, et al. Autonomic impairment of patients in coma with different Glasgow coma score assessed with heart rate variability. *Brain Inj.* 2019;33(4):496-516.
46. Machado-Ferrer Y, Estevez M, Machado C, Hernandez-Cruz A, Carrick FR, Leisman G, et al. Heart rate variability for assessing comatose patients with different Glasgow Coma Scale scores. *Clin Neurophysiol.* 2013;124(3):589-97.
47. Arhan E, Serdaroglu A, Hirfanoglu T, Kurt G. Aggravation of seizures and status epilepticus after vagal nerve stimulation therapy: the first pediatric case and review of the literature. *Childs Nerv Syst.* 2018;34(9):1799-801.
48. Healy S, Lang J, Te Water Naude J, Gibbon F, Leach P. Vagal nerve stimulation in children under 12 years old with medically intractable epilepsy. *Childs Nerv Syst.* 2013;29(11):2095-9.
49. Hauptman JS, Mathern GW. Vagal nerve stimulation for pharmacoresistant epilepsy in children. *Surg Neurol Int.* 2012;3(Suppl 4):S269-74.
50. Grioni D, Landi A. Does Vagal Nerve Stimulation Treat Drug-Resistant Epilepsy in Patients with Tuberous Sclerosis Complex? *World Neurosurg.* 2019;121:251-3.
51. Gigliotti MJ, Mao G, Dupre DA, Wilberger J. Vagal Nerve Stimulation: Indications for Revision in Adult Refractory Epilepsy. *World Neurosurg.* 2018;120:e1047-e53.
52. Kraimer KL, Kochanski RB, Lynn F, Smith M, Sani S. Abdominal Epilepsy Treated With Vagal Nerve Stimulation: A Case Report. *Oper Neurosurg (Hagerstown).* 2018.

**Author Information**

**Calixto Machado, MD, PhD, FAAN**

Institute of Neurology and Neurosurgery, Department of Clinical Neurophysiology  
Havana, Cuba

**Yanín Machado, MD**

Institute of Neurology and Neurosurgery, Department of Clinical Neurophysiology  
Havana, Cuba

**Mauricio Chinchilla, MD**

Institute of Neurology and Neurosurgery, Department of Clinical Neurophysiology  
Havana, Cuba

**Yazmina Machado, MD**

“Manuel Piti Fajardo” Hospital  
Havana, Cuba

**Hector Foyaca-Sibat, MD, PhD**

Full Professor and Full Scientist Research, Head of Department of Neurology, Walter Sisulu University  
South Africa