Obstructive sleep apnea (OSA) is the most common sleep respiratory disturbance. It is widely recognized as a risk factor for cardiovascular diseases. It usually presents with excessive daytime sleepiness, increasing the risk of accidents at work and transit. The prevalence of OSA continues to increase, imposing a global burden on public health and currently affects 10% of middle-aged men and 3% of women.1

The main focus to treat OSA is to keep a continuous positive pressure in upper airways (CPAP—continuous positive airway pressure), besides weight loss; however, CPAP is not tolerable for long periods (a quarter of patients do not adjust within a few weeks and half of all patients quit after 1 year).2 The causes of abandonment of OSA treatment with CPAP range from subjective complaints: discomfort (yarn, mask, noise), embarrassment, resistance to use, and prejudice to real complaints such as airway dryness, worsening of nasal conditions, feeling of suffocation, and stress, besides the high cost and successive maintenance of the device.

Other therapies are needed to reduce the symptoms that are not treated by CPAP. Among them, oral appliances for mandibular advancement are the most important ones, which have been the treatment of choice after CPAP. Oral appliances have been indicated in cases of failure to use CPAP in mild and/or moderate OSA and are equally effective in the treatment of OSA compared to CPAP. The mandibular advancement obtained with oral appliances increases the traction of the musculature, maintaining the airway opened. Unfortunately, there are few limitations for the use of oral appliances: dental and periodontal problems, temporomandibular joint disorder, and short- and long-term occlusal alterations of which we do not yet have clear answers to date due to a small number of long-term studies.3

So, what would it be the next option to treat OSA when CPAP and oral appliances fail? What other methods can maintain muscle tonus during sleep?

As early as 1978, Remmers et al described the pathophysiology of upper airway obstruction in sleep apnea.4 Since then, research groups have observed that electrical stimulation of the upper airways may result in an increased tonus of the upper airway dilator muscles, thus allowing patients to keep the upper airway unobstructed during sleep.5

Hida et al, back in 1994, demonstrated that submental stimulation improved breathing disturbance, sleepiness in the daytime, and sleep quality.5 In 2014, stimulation of the hypoglossal nerve using an implantable stimulator was approved by the US Food and Drug Administration for the treatment of OSA following the results of the STAR trial.1 However, hypoglossal nerve stimulation is a surgically implantable electrode close to the hypoglossal nerve, therefore, a risky and costly procedure with many unwanted side effects, such as paresthesia, hypertonia of the tongue, successive arousals, hypersalivation, and fatigue muscle.

Previously, Miki et al demonstrated that transcutaneous electrical stimulation was effective in reducing the index and duration of sleep apnea and improved oxygen saturation.6 Currently, there are many ways to stimulate upper airway dilator muscles: (a) invasively or not, (b) cyclical or continuous stimulation, (c) high- or low-intensity current, (d) neural or muscular stimulation, (e) variable frequencies of the current, (f) variable pulses, (g) uni- or bilateral stimulation, and (h) unipolar or bipolar current.7 In 2011, a study showed that continuous transcutaneous electrical stimulation (CTES) was a viable and effective approach to stimulate the upper airway dilator muscles during sleep.5

Hu et al used a biphasic electrical nerve stimulator consisting of an electric pulse generator, an apnea sensor, and percutaneous electrodes.8 Twenty-two patients with severe OSA were included and tested the device during a split-night study. Each device was triggered if no nasal flow was detected for at least 5 seconds. The mean respiratory distress index decreased from 30.9/hour to 12.4/hour, while pacing was administered without significant changes in the micro-arousal index.

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Pengo and Steier carried out the first randomized continuous electrical stimulation study in 366 patients (mean age: 50.8 years), both sexes, mean body mass index 29.6 kg/m², Epworth Sleepiness Scale 10.5 points, median oxygen desaturation index 25.7/hour (range: 16.0-49.1), and median apnea–hypopnea index 28.1/hour (range: 19-57). The primary outcome improved when simulated stimulation (median: 26.9/hour; range: 17.5-39.5) was compared with active treatment (median: 19.5/hour; range: 11.6-40.0; \( P = .026 \)), a modest mean reduction of 4.1/hour (95% CI: −0.0 to 8.9). Secondary outcomes on patient perception results indicated that electrical stimulation was well tolerated. Respondents (47.2%) were predominantly mild to moderate OSA. In this subgroup, the oxygen desaturation index was reduced by 10.0/hour (95% CI: 3.9-16.0; \( P < .001 \)), and the apnea–hypopnea index was reduced by 9.1/hour (95% CI: 0-16.2; \( P = .004 \)). They concluded that CTES of pharyngeal dilators muscles during a single night in patients with OSA improves upper airway obstruction and is well tolerated.

Currently, there are 7 studies that evaluated transcutaneous electrical stimulation for the treatment of OSA, and of these, only one randomized study evaluated continuous electric stimulation throughout the night.\(^6\-^{12}\) Therefore, although electrical stimulation has been shown to be effective among adults, the best moment to introduce this strategy is not known yet: whether continuous or intermittent; what levels of electrical stimulation for different degrees of apnea, associated comorbidities, age groups, and obesity; and its effects in the medium and long term.

Although the earliest study on electric stimulation dates back to the 1980s, few answers have been given since then about its mechanisms. More complex studies are needed to bring light to these unanswered questions. And perhaps transcutaneous electrical stimulation may emerge as a new alternative in OSA when CPAP and oral appliance fail. Is transcutaneous electrical stimulation a light at the end of the tunnel?

**Authors’ Note**

The authors confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. The authors further confirm that the order of authors listed in the manuscript has been approved by all of us. The authors confirm that they have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing, the authors confirm that they have followed the regulations of the institutions concerning intellectual property. The authors further confirm that any aspect of the work covered in this manuscript that has involved either experimental animals or human patients has been conducted with the ethical approval of all relevant bodies and that such approvals are acknowledged within the manuscript. The authors understand that the corresponding author is the sole contact for the editorial process (including Editorial Manager and direct communications with the office). He is responsible for communicating with the other authors about progress, submissions of revisions, and final approval of proofs. The authors confirm that they have provided a current, correct e-mail address which is accessible by the corresponding author and which has been configured to accept e-mail from: almiromachadophd@gmail.com

**References**

1. Steier J, Martin A, Harris J, Jarrold I, Pugh D, Williams A. Predicted relative prevalence estimates for obstructive sleep apnoea and the associated healthcare provision across the UK. Thorax. 2014;69(4):390-392.
2. Crawford MR, Espie CA, Bartlett DJ, Grunstein RR. Integrating psychology and medicine in CPAP adherence—new concepts? Sleep Med Rev. 2014;18(2):123-139.
3. Machado AJ Jr, Pauna HF, Crespo AN. Oral appliance in obstructive sleep apnea syndrome. Sleep Med. 2017;32:122-123.
4. Remmers JE, deGroot WJ, Sauerland EK, Anch AM. Pathogenesis of upper airway occlusion during sleep. J Appl Physiol Respir Environ Exerc Physiol. 1978;44(6):931-938.
5. Hida W, Okabe S, Miki H, et al. Effects of submental stimulation for several consecutive nights in patients with obstructive sleep apnoea. Thorax. 1994;49(5):446-452.
6. Miki H, Hida W, Chonan T, Kikuchi Y, Takishima T. Effects of submental electrical stimulation during sleep on upper airway patency in patients with obstructive sleep apnea. Am Rev Respir Dis. 1989;140(5):1285-1289.
7. Edmonds LC, Daniels BK, Stanson AW, Sheedy PF III, Shepard JW Jr. The effects of transcutaneous electrical stimulation during wakefulness and sleep in patients with obstructive sleep apnea. Am Rev Respir Dis. 1992;146(4):1030-1036.
8. Hu L, Xu X, Gong Y, et al. Percutaneous biphasic electrical stimulation for treatment of obstructive sleep apnea syndrome. IEEE Trans Biomed Eng. 2008;55(1):181-187.
9. Pengo MF, Steier J. Emerging technology: electrical stimulation in obstructive sleep apnoea. J Thorac Dis. 2015;7(8):1286-1297.
10. Pengo MF, Xiao S, Ratneswaran C, et al. Randomised sham-controlled trial of transcutaneous electrical stimulation in obstructive sleep apnoea. Thorax. 2016;71(10):923-931. doi:10.1136/thoraxjnl-2016-208691.
11. Guilleminault C, Powell N, Bowman B, Strohs R. The effect of electrical stimulation on obstructive sleep apnea syndrome. Chest. 1995;107(1):67-73.
12. Steier J, Seymour J, Rafferty GF, et al. Continuous transcutaneous submental electrical stimulation in obstructive sleep apnea: a feasibility study. Chest. 2011;140(4):998-1007.