ELECTRONCS AND ELECTRICAL ENGINEERING
ISSN 1392 – 1215 *2009. No. 5(93)*
ELEKTRONIKA IR ELEKTROTECHNIKA

MEDICINE TECHNOLOGY
T 115
MEDICINOS TECHNOLOGIJA

Signals and Systems for Electrosleep

D. Tz. Dimitrov, N. D. Ralev
Faculty of Telecommunication, Technical University
Sofia,8, "Kliment Ohridsky" str., 1000 Sofia,Bulgaria, E-mail: dcd@tu-sofia.bg

Introduction

Cranial Electrotherapy Stimulation (CES) is the application of low-level pulsed electrical currents (usually less than 1mA) applied to the head for medical and/or psychological purposes. There is now over 20 years of medical experience with CES in America. Presently, its use requires a prescription by a licensed health practitioner in the United States. It is available without a prescription throughout the rest of the world. Cranial electrotherapy stimulation has also been known by many other names. Transcranial electrotherapy (TCET), neuroelectric therapy (NET), alpha sleep, electroanalgesia, electronarcosis and the original electrosleep just a few of the more common terms that have referred to the same therapy.

Cranial electrotherapy stimulation was first called electrosleep because it was thought to induce sleep. Rabinovich, a Russian, is given credit for making the first claim for electrical treatment of insomnia in 1914. In 1957, in the formed U.S.S.R., Anan'ev published the first paper on CES. The first book, simply titled Electrosleep, was published a year later by Gilyarovski. This generated a high degree of interest in the then-known Eastern Block countries and CES was soon adopted as a treatment modality. In 1959, Obrosow reviewed the CES literature and published the first American paper on CES. By 1966 the first International Symposium on Electrotherapeutic Sleep and Electroanesthesia was held in Austria. The use of CES had spread worldwide by the late 1960's when animal studies of CES began in the U.S. at the University of Tennessee, and at what is now the University of Wisconsin Medical School. These were soon followed by human clinical trials at the University of Texas Medical School in San Antonio, the University of Mississippi Student Counseling Center and the University of Wisconsin Medical School. Scientists at Harvard have recently analyzed all the literature on CES worldwide, and have also found it to be an effective therapy although they are holding their findings confidential until their results are published. Open marketing of CES devices began in the 1970's in the U.S. for the treatment of anxiety, depression and insomnia. Several thousand Americans are treated with CES annually by thousands of doctors and it is estimated that more than 50,000 people in the U.S. own CES devices which have been prescribed for home use. No adverse effects or contraindications have been found from the use of CES, either in the U.S. or in other parts of the world. As with all electrical devices, caution is advised during pregnancy and for patients with a demand-type pacemaker. In addition, it is recommend that patients not operate complex machinery or drive automobiles during and shortly after a CES treatment.

Cranial electrotherapy stimulation is believed to stimulate the production of endorphins. It probably also affects the hypothalamus causing changes in the hypothalamic neurohormonal regulatory mechanisms and the reticular formation of the brain stem. The reticular activating system is involved in a myriad of behavioral expressions from alertness to sleep. This attentional center" plays an important integrative role in the functioning of mind and body.

Methods

After approval from a hospital for rehabilitation, patients 22-75 years of age presenting at the LSU Pain Clinic with a diagnosis of fibromyalgia were randomly assigned to either a Sham Group or a Cranial Electrotherapy Stimulation (CES) Group. The diagnosis of fibromyalgia was verified using the criteria set forth by the American College of Rheumatology. Exclusion criteria included pregnancy and presence of implanted pacemakers, pumps, or stimulators, as well as the presence of superficial or internal ear infections. No change was made in the medical management of the patient during the study. All patients were given a CES device that would provide either subsensation treatment or sham treatment. Each device was preset to provide 1 hour of 100 μA, modified square-wave biphasic stimulation on a 50% duty cycle at 0.5 Hz, and to automatically turn off at the end of one hour. All treatment was given via electrodes clipped to the ear lobes. Location of electrodes on the ear lobes is illustrated in Fig. 1.

Sham treatment was provided by identical ear clip electrodes that did not pass current. All staff, the physicians, and the patient were blind to the treatment conditions. At the end of three weeks, the CES Group was

unblinded, and the Sham Group was given the option to receive active therapy for an additional three weeks.

Fig. 1. Location of electrodes on the ear lobes

Sleep patterns should begin to normalize within the first day or two, with less and shorter periods of awakening during the night, faster onset of sleep after going to bed, and a greater feeling of being rested upon awakening the following morning. Depression and mood swings become less, as does irrational anger, irritability, and poor impulse control. By the second week, cognitive processing is visibly enhanced. Mental confusion due to stress begins to subside as the ability to focus and concentrate on work becomes easier and more efficient. The ability to recall information and accelerate learning also begins to return to normal pre-stress levels as concentration and memory improve. There are no known contraindications for use of CES. However, there are circumstances in which its safety has not been tested. Accordingly, CES should not be used without on-going clinical supervision by severe depressives and those known to be epileptic, pregnant, or those using implanted electronic devices such as cardiac pacemakers or insulin pumps.There have, however, been instances where under such supervision CES has been employed successfully and where CES has been shown to reduce both the frequency and severity of seizures.

Because of the feeling of induced relaxation that results while using CES, though, this relaxation response does not in any way impair reaction time, it is recommended that CES not be used while operating dangerous or complex equipment or while driving.CES treatment may result indirectly in increased blood flow to the brain. Hence its possible contraindication in recent hemorrhagic stroke patients. This same effect can cause brief increased blood flow beneath the electrodes behind the ears. This redness should not be cause for concern. This is an extremely rare occurrence. It is not a burn response and will go away shortly after the CES treatment is finished if it occurs at all.

Signals and devices for cranial electrotherapy stimulation.

Cranial electrotherapy stimulation devices are generally similar in size and appearance to standard transcutaneous electrical nerve stimulators (TENS), but produce very different waveforms. Standard milliampere-current TENS devices must never be applied transcranially. CES electrodes can be placed bitemporally, bilaterally in the hollow behind the ears just anterior to the mastoid processes, or clipped to the earlobes. This depends on the device being used. Most CES devices should produce a pulse repetition rate (PRR) of 100 Hz which was what the original Russian devices used. Some produce a PRR as low as 0.5, or as high as 15,000 Hz. The current is usually increased by the patient until a mild tingling sensation is felt at the electrode site, or a slight vertigo (dizziness) is experienced. It is then adjusted back down to a comfortable level below that which produces vertigo or an unpleasant feeling of electrical current. It may take a few minutes before the current needs to be reduced. Generally, a treatment time of 20 to 40 minutes is best, daily or every other day. Immediately after a CES treatment, patients usually report feeling more relaxed. Some people feel somewhat inebriated for the first few minutes. This is a pleasant and very comfortable sensation. After several minutes to hours, the light-headed feelings usually disappear, the relaxed state remains and a profound sense of alertness is achieved. This relaxed/alert state will usually remain for an average of 12 to 72 hours after the first few treatments and then becomes cumulative from a series of treatments. Most patients relate feeling more relaxed, less distressed, while their minds remain alert and even more focused on mental tasks. They generally sleep better and report improved concentration along with heightened states of general well-being.

Cranial Electrotherapy Stimulators

Most CES units are user friendly. After having put on either the electrodes or the ear-clips and inserted the lead wire into the jack, it's all very simple. CES units either feature an on-off knob that also controls the amplitude (turning it to the right increases the amount of current) as in the 100 Hz devices. They use a button that turns the unit on and a side wheel that increases the amplitude). Start with a low current and gradually increase it. If the current is too high, the patient may experience a stinging at the electrodes, dizziness or nausea. If any of these symptoms occur, simply reduce the current and the symptoms will immediately subside. After a minute or two, try increasing the current again, but always keep it at a comfortable level. It's ok to feel the current providing it is not uncomfortable. CES is the most popular technique for electrically boosting brain power, and has long been prescribed by physicians for therapeutic reasons, including the treatment of anxiety, depression, insomnia, and chemical dependency. A CES unit (Fig.2) generates an adjustable current of 80 to 600 μA that flows through clips placed on the earlobes. The waveform of this device is a 400 milliseconds positive pulse followed by a negative one of the same duration, then a pause of 1.2 seconds. The main frequency is 0.5 Hz, i.e. a double pulse every 2 seconds. IC1 forms a narrow pulse, 2.5Hz oscillator feedings IC2. This chip generates the various timings for the output pulses. Output is taken at pins 2 & 3 to easily obtain negative going pulses also.

Current output is limited to 600µA max. by R2 and can be regulated from 80 to 600µA by means of R3. The LED flashes every 2 seconds signaling proper operation and can also be used for setting purposes. It can be omitted together with R4, greatly increasing battery life. Notes:

- In order to obtain a more precise frequency setting take R1=1M2 and add a 500K trimmer in series with it.
- In this case use a frequency meter to read 2.5Hz at pin 3 of IC1, or an oscilloscope to read 400msec pulses at pins 2, 3 or 10 adjusting the added trimmer.
- A simpler setting can be made adjusting the trimmer to count exactly a LED flash every 2 seconds.
- Earclips can be made with little plastic clips and cementing the end of the wire in a position suited to make good contact with earlobes.
- Ultra-simple earclips can be made using a thin copper foil with rounded corners 4 cm. long and 1.5 cm. wide, soldering the wire end in the center, and then folding it in two parts holding the earlobes.
- To ensure a better current transfer, this kind of devices usually had felt pads moistened with a conducting solution interposed between clips and skin.

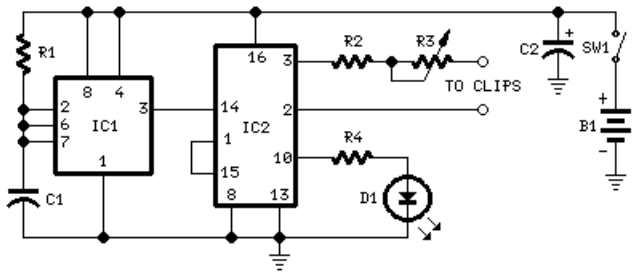

Fig. 2. Cranial Electrotherapy Stimulator

CES is an FDA registered treatment modality in which micro electric impulses are applied to the head. Cranial electrotherapy stimulation (CES) involves the passing of small electrical impulses across the head, usually from electrodes placed on or near the ears. The pulse rates vary from 0.5-100 Hz in different CES devices, and stimulation intensities range from 0-1.5 mA via sinusoidal or modified square waves. The duty cycles range from 20-80%, with most devices pulsing on a 50% duty cycle. A common CES configuration is 100 Hz with a maximum current output of 1.5 mA, current amplitude similar to that in the human body. The primary indications for use of CES are stress and stress related disorders, primarily anxiety, depression, and insomnia. CES has shown itself to be particularly effective in addressing those symptoms in the context of a variety of illnesses, including substance withdrawal syndrome, chronic fatigue syndrome, attention deficit disorder syndrome, and generalized anxiety and panic disorders. Cranial Electrotherapy Stimulation (CES) is a process which utilizes minute electrical stimulation for therapeutic purposes. Low voltage electrical stimulation of the brain has proven to be therapeutically beneficial in the treatment of numerous conditions such as depression, anxiety, substance abuse, withdrawal syndrome, and insomnia. Because these symptoms are so widespread in a variety of psychiatric diagnoses, CES is a useful adjunct in treating schizophrenia, learning disability, hyperactivity, even hyperacidity

According to the last medical investigations a good result of CES (especially for electro-sleep) can be obtained in the case of increasing of patient's current to 1,5mA or more , but not more than 3mA. In some cases it would be better to use "movement" of rectangular electrical pulses. Therefore two modes of work can be provided by apparatus for electro-seep. The electrical pulses should be provided simultaneously in all cranial electrodes (Fig. 3a).

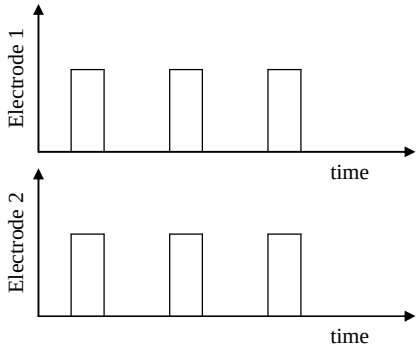

Fig. 3a. Simultaneously providing of electrical pulses in cranial electrodes

In the case of "movement" of electrical pulses they should be provided to the first pear cranial electrodes, then the same electrical pulses should be provided to the second pear cranial electrodes (Fig.3b).

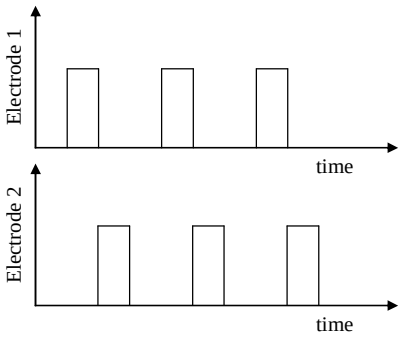

Fig. 3b. "Movement" of electrical pulses

The value of patient's current can be determined by physician. The apparatus should provide permanent monitoring of this during the procedure by indicator . The value of patient's current should be not more than 3mA. The electrical source of CES systems should be always accumulator. It should provide permanent work of CES system for more than 12h. Therefore it would be better to upgrade in apparatus a device for restoration of accumulator. This restoration should be provided when the CES system not work.

In many cases the final effect of CES (especially for electro-sleep) can be better if there is a permanent change of frequency of rectangular pulses. Therefore it's necessary to provide appropriate microprocessor system initial electrical pulses for different cranial electrodes. The change of pulse frequency can be manual or automatic. The described apparatus for electro-sleep can provide electrical pulses with frequency from 0,1Hz to 150Hz. The mistake (deviation) of frequency can be seen on Fig. 4.

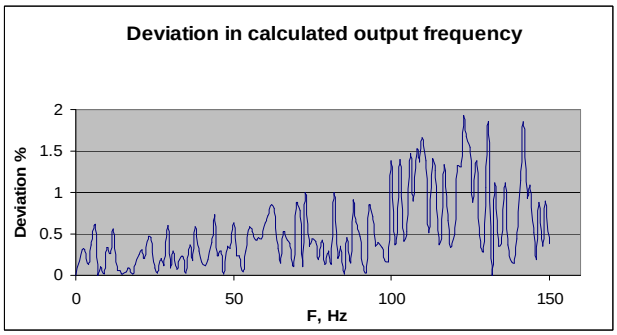

Fig. 4. The mistake (deviation) of frequency

The permanent monitoring of frequency value is provided by display. The apparatus for electro-sleep can be seen on Fig.5

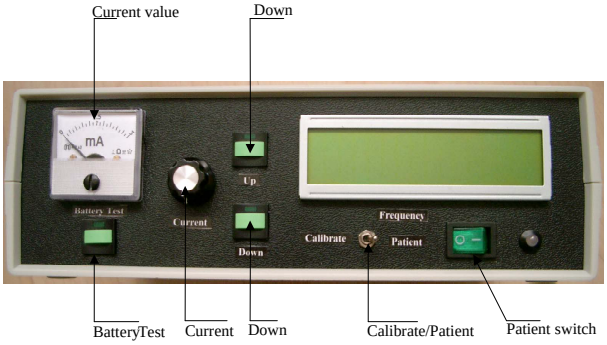

Fig. 5. The apparatus for electro-sleep

Conclusion

CES appears to be an effective, well-tolerated treatment for the treatment of fibromyalgia. It could be just a matter of improved sleep patterns, which CES has been shown to induce.Now , in the last years there are many new investigations on CES as one simple and user friendly method for therapy. The results of these medical investigations are one good base for creation of new modifications of signals and systems for CES and especially for electro-sleep.

References

1. **Kirsch D. L. and Smith R. B.** The use of cranial electrotherapy stimulation in the management of chronic pain: A review // NeuroRehabilitation. – 2000. – Vol. 14. – P. 85–94.
2. **Winick R. L.** Cranial electrotherapy stimulation (CES): a safe and effective low cost means of anxiety control in a dental practice // Gen. Dent. – 1999. – Vol. 47. – P. 50–55.
3. **Lichtbroun A.S., Raicer M. C. and Smith R. B.** The treatment of fibromyalgia with cranial electrotherapy stimulation // J. Clin. Rheumatol. – 2001. – Vol. 7. – P. 72–78.
4. **Hozumi S., Hori H., Okawa M., Hishikawa Y. and Sato K.** Favorable effect of transcranial electrostimulation on behavior disorders in elderly patients with dementia: a double-blind study // Inter. J. Neurosci. – 1996. – Vol. 88. – P. 1–10.
5. **Southworth S.** A study of the effects of cranial electrical stimulation on attention and concentration // Integr. Physiol. Behav. Sci. – 1999. – Vol. 34. – P. 43–53.
6. **Schroeder M. J. and Barr R. E.** Quantitative analysis of the electroencephalogram during cranial electrotherapy stimulation // Clin. Neurophysiol. – 2001. – Vol. 112. – P. 2075–2083.

Received 2009 03 05

D. Tz. Dimitrov, N. D. Ralev. Signals and Systems for Electrosleep // Electronics and Electrical Engineering. – Kaunas: Technologija, 2009. – No. 5(93). – P. 95–98.

An investigation on Cranial System for Electro-stimulation (CES) has been done. Methods for CES with application of different electrical signals and with different application of patient's electrodes have been done also. Some devices for CES are described. A new apparatus for electro-sleep has been described. The requirements concerning the values of different parameters of signals and systems for electro-seep have been done in the paper as one base for engineering design of cranial systems for electro-stimulation and especially design of apparatus for electro-sleep. Ill. 5, bibl. 6 (in English; summaries in English, Russian and Lithuanian).

Д. Ц. Димитров, Н. Д. Ралев. Сигналы и системы для электросна // Электроника и электротехника. – Каунас: Технология, 2009. – № 5(93). – С. 95–98.

Описываются исследования систем для электростимуляции мозга. Приводятся разные методы, разные электрические сигналы, разные расположения пациентных электродов на голове. Описываются разные устройства для электростимуляции головного мозга. Описан и новый аппарат для электросна. Даны требования к параметрам аппаратов для электростимуляции головного мозга (в том числе аппаратов для эелектросна) в процессе их проектирования. Ил. 5, библ. 6 (на английском языке, рефераты на английском, русском и литовском яз.).

D. Tz. Dimitrov, N. D. Ralev. Elektroninio miego stimuliatoriaus signalai ir sistemos // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2009. – Nr. 5(93). – P. 95–98.

Aprašomi elektroninei smegenų stimuliacijai skirtų sistemų tyrimai. Pateikti skirtingi metodai, elektriniai signalai, elektrodų išdėstymo ant paciento galvos taisyklės. Aprašomi galvos smegenų elektrinei stimuliacijai atlikti naudojami prietaisai bei naujas tokio prietaiso modelis. Pateikti tokių aparatų parametrams ir jų projektavimui keliami reikalavimai. Il. 5, bibl. 6 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).