

# Objectivation of cerebral effects with a new continuous electrical auricular stimulation technique for pain management

J. Constantin Széles\* and Gerhard Litscher†

\*Department of Vascular Surgery, Medical University of Vienna, Austria

†Department of Biomedical Engineering and Research in Anesthesia and Critical Care, Medical University of Graz, Austria

**Aims:** The electrical point stimulation system (P-STIM®) reflects a new, miniaturized system for pain therapy through ear acupuncture. For this reason, ultrathin needles were applied at the ear. The needles stimulate the acupuncture areas at the ear using electrical impulses, which come from a little generator applied behind the acupunctured ear.

**Methods:** This study describes continuous, non-invasive measurements of near infrared spectroscopy (NIRS) and multidirectional transcranial Doppler sonography in two healthy females (aged 23 and 27 years) during stimulation with P-STIM®, for the first time.

**Results:** The results of the pilot measurements have shown that electrical point stimulation using the new electrical stimulation system on eye acupuncture points is able to modulate the mean blood flow velocity ( $v_m$ ) of the supratrochlear artery. These effects were present using a stimulation frequency of 100 Hz. A lower increase in  $v_m$  was found in the middle cerebral artery. In addition, stimulus induced, quantifiable and reproducible alterations of the regional cerebral NIRS parameters were detected.

**Conclusion:** For the first time, P-Stim® allows intermittent ear acupuncture stimulation for up to several days in combination with complete mobility for the patient. [Neurol Res 2004; 26: 797–800]

**Keywords:** Point stimulation; electro-acupuncture; ear acupuncture; electrical ear stimulation; pain; neuromonitoring

## INTRODUCTION

Pain is the most common reason for ear acupuncture<sup>1</sup>. In recent times, investigation and quantification of the effects of acupuncture were done using modern biomedical methods. Evidence for measurable alterations in the brain using acupuncture stimulation can be found in previous reports by our research group<sup>2–15</sup>.

A new method for pain treatment using ear acupuncture is the electrical point stimulation system P-STIM® (Biegler, Austria). Ultrathin permanent needles are applied to the ear. A generator, located behind the acupunctured ear, produces electrical stimulation impulses, which are transferred via the needles to the acupuncture areas (Figure 1). The ear is chosen because concentrations of free nerve ends/acupuncture points are located there<sup>16</sup>. In the past, traditional acupuncture and electro-acupuncture were characterized by the fact that these methods were confined to a clinic and/or the physicians practice. P-STIM® allows continuous,

intermittent stimulation for up to several days combined with absolute mobility of the patient.

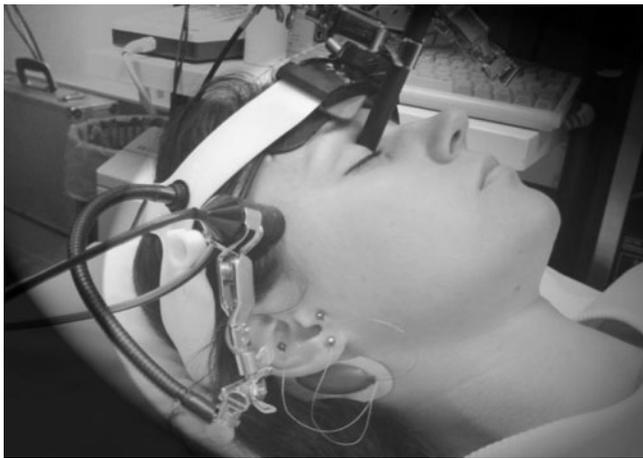
In this study, selective and specific effects of electrical point stimulation in the brain using P-STIM®, were investigated on healthy volunteers, using multidirectional transcranial Doppler sonography (TCD) and near infrared spectroscopy (NIRS). Simultaneous and continuous blood flow profiles in different cerebral vessels were monitored using TCD (compare Figure 1). Using NIRS, we registered changes of cerebral oxygen metabolism continuously after different stimulation frequencies.

## MATERIALS AND METHODS

An expert in traditional Chinese acupuncture and ear acupuncture selected acupuncture points on the ear, for the eye and liver region (compare Figure 1). A position tape prepared previously with the P-STIM® application pointer was applied. This procedure was repeated until all the acupuncture points were marked. Then, the needles could be taken up by the application pointer and applied (Figure 2, lower left).

A physician adheres the actual device behind the acupunctured ear with the integrated adhesive electrode (compare Figures 1 and 2). Then, the wires are

Correspondence and reprint requests to: J. Constantin Széles, MD, Department of Vascular Surgery, Medical University of Vienna, Währinger Gürtel 18–20, A-1090 Wien/Austria [j.szeles.akh@aon.at] or Gerhard Litscher, Prof. PhD, Department of Biomedical Engineering and Research, in Anesthesia and Critical Care, Medical University of Graz, Auenbruggerplatz 29, A-8036 Graz/Austria. [gerhard.litscher@meduni.graz.at] Accepted for publication January 2004.



**Figure 1:** Electrical point stimulation. Pilot measurements at the Department of Biomedical Engineering and Research in Anaesthesia and Critical Care at the Medical University of Graz (with friendly approval of the volunteer)



**Figure 2:** P-STIM® electrical point stimulation system and probe holder construction for the experimental transcranial ultrasound spectroscopic and near infrared spectroscopic investigations

connected to the permanent needles by snapping over the plastic rings (*Figure 2*, right) and are fastened with adhesive tape. Finally, P-STIM® is activated by removing the adhesive foils from the batteries and by opening the lid.

The stimulation patterns in *Table 1* were available.

For TCD-registrations, a special, multidirectional spectacle probe holder prototype was constructed (compare *Figures 1* and *2*, left). This allowed the continuous recording of cerebral blood flow velocities of the supratrochlear artery (STA) and the middle cerebral artery (MCA). The ultrasound signals were registered with the Multi-Dop T system from DWL

Electronic Systems GmbH, Sipplingen, Germany. A 2 (MCA) and a 4 MHz (STA) probe were both used.

The lowest frequency value was used for the investigation of the vessels near the eye; the assessable signals were a maximum 20 mW/cm<sup>2</sup>. Monitoring of the TCD signals from the STA was carried out using a scanning probe connected to a special holder at the median angle of the eye, which was positioned slightly medial and parietal and without pressure<sup>17</sup>. Using acoustic control, the angle and positioning of the probe was altered until the greatest signal amplitude was achieved. In addition, simultaneous and continuous alterations in blood flow velocity of the MCA were determined. The most important assessable parameters are alterations in the mean blood flow velocity ( $v_m$ ). At the same time, different parameters of NIRS (NIRO 300, Hamamatsu Photonics, Hamamatsu, Japan) determined the regional cerebral oxygenation in frontal areas of the brain<sup>3,7,10,12-15</sup>.

Two healthy volunteers aged 23 and 27 years took part in this investigation. They were positioned, relaxed on a bed during the investigation.

This study was performed with the approval of the Ethic Commission at the Medical University of Graz (13-016 ex 02/023 "Punctual stimulation").

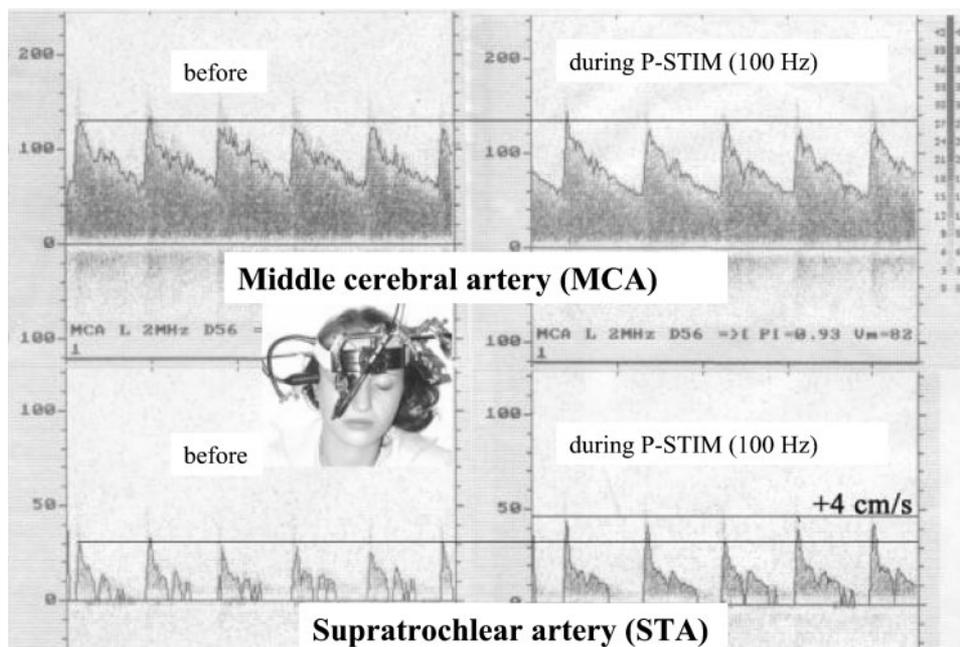
**Table 1:** Possible stimulation patterns with P-STIM®

Program	Stimulation pattern
P1: endless	15 minutes stimulation with 100 Hz/260 $\mu$ S 30 minutes pause
P2: four times	15 minutes stimulation with 100 Hz/260 $\mu$ S 30 minutes pause Four times 3 hours stimulation with 1 Hz/20 mS 3 hours pause
P3: four times	15 minutes stimulation with 100 Hz/260 $\mu$ S 30 minutes pause Four times 10 minutes pause 5 minutes stimulation with 50 Hz/260 $\mu$ S 30 minutes pause 3 hours stimulation with 10 Hz/2 mS 3 hours pause 3 hours stimulation with 1 Hz/20 mS 3 hours pause
P4: endless	15 minutes stimulation with 100 Hz/260 $\mu$ S 15 minutes pause 15 minutes stimulation with 1 Hz/20 mS 15 minutes pause

## RESULTS

*Figure 3* shows the blood flow profiles in the right MCA and left STA of the 23-year-old female volunteer, before and during 100 Hz point stimulation with P-STIM®. According to multidirectional transcranial and orbital ultrasound scanning, the mean blood flow velocity in the MCA remained unchanged. However, in the STA, an increase in flow velocity of +4 cm/s occurred during point stimulation at this frequency. This change could not be documented at a stimulation frequency of 1 Hz. About 5 minutes after terminating electric stimulation, the initial results were achieved again.

NIRS initially showed a minor decrease in O<sub>2</sub>Hb (oxyhemoglobin) in the second (27-year-old female)

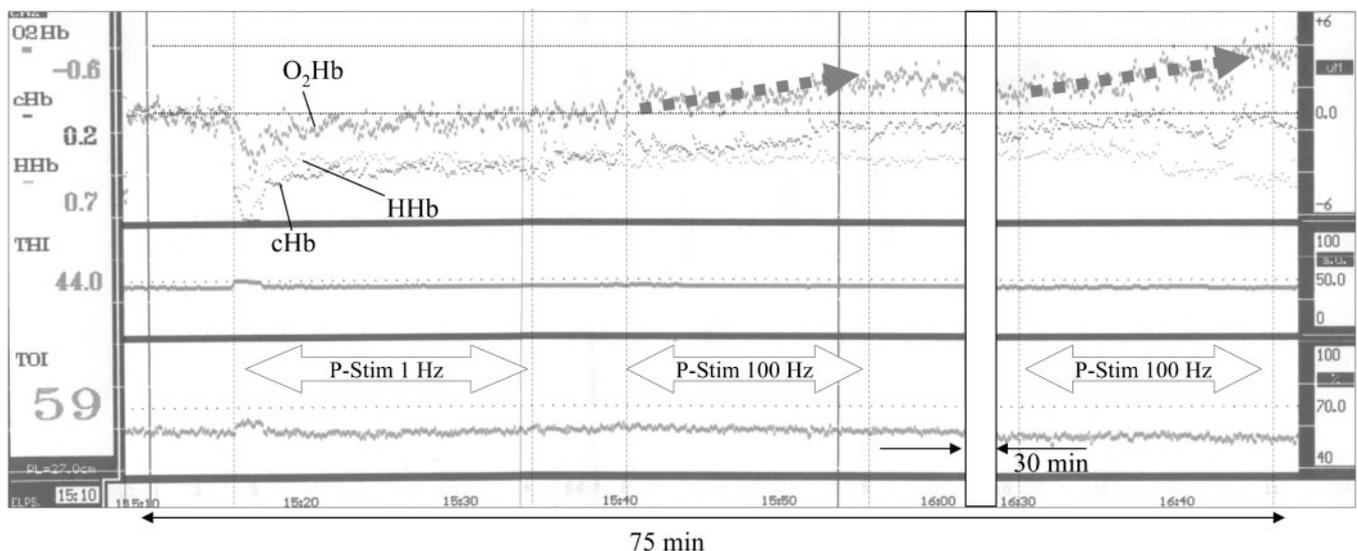


**Figure 3:** Multidirectional transcranial and orbital sonography investigations before and during the point stimulation (with friendly approval of the volunteer). Blood flow profiles of the MCA and the STA from a female, 23-year-old volunteer, before and during point stimulation. Observe the increase in blood flow velocity during stimulation using 100 Hz

volunteer during point stimulation of the ear at a stimulation frequency of 1 Hz. Immediately after stimulation, the O<sub>2</sub>Hb values again reached their initial range. During electric ear stimulation with a frequency of 100 Hz, an obvious increase in O<sub>2</sub>Hb was registered for this volunteer. This effect could again be observed in the same person after a delay of >30 minutes. In addition, a stimulation-induced influence on the NIRS parameters in the sense of an accumulation of the repeated stimulation of 100 Hz (compare Figure 4, middle and right) could be detected.

#### DISCUSSION

At the end of the 1950s, French physician Dr Paul Nogier further developed ear acupuncture. Nogier systematically proved that different regions of the ear and specific organs have definite functional relationships and dependencies. As a result of these relationships, using a needle on one or more ear acupuncture points can be performed to treat specific organs or organic functions; on the other hand, ear acupuncture points are also relevant for diagnostics in the field of auricular medicine. According to Nogier, a change in skin



**Figure 4:** NIRS during point stimulation with P-STIM® at the ear of a 27-year-old female volunteer. Observe the reproducible increase in O<sub>2</sub>Hb during the electrical stimulation with a frequency of 100 Hz (O<sub>2</sub>Hb, oxyhemoglobin; cHb, total hemoglobin; HHb, deoxyhemoglobin; THI, tissue hemoglobin index; TOI, tissue oxygenation index)

resistance at certain areas of specific ear acupuncture points is present in particular organic diseases<sup>16</sup>.

This study introduces a new, miniaturized system (P-STIM<sup>®</sup>) for continuous electric point stimulation of the ear. Based on measurement data from two healthy female volunteers using TCD and NIRS, the influence on cerebral function could be observed. As already mentioned above, electrical point stimulation allows continuous, intermitting electrical stimulation at ear acupuncture points for up to several days. During its use, the patient is guaranteed complete mobility, which is not the case when using other systems.

The auricular-stimulation method could be important in treating chronic pain. Moreover, this concept seems to be useful for treating addiction, allergies and special areas of anesthesiology<sup>18–21</sup>.

The initial studies with point stimulation<sup>18–21</sup> used a P-STIM<sup>®</sup>, combined with reusable needles. Because of hygiene and discomfort during usage, we used one-use instruments and needles in this study.

The first interim results<sup>18</sup> of a clinical, point-stimulation study showed that a marked decrease in the VAS (Visual Analog Score) scale of pain occurred in 31 people who underwent electric stimulation. The average duration of stimulation was 36.6 hours at a treatment time of 18–72 hours. A significant decrease in the VAS scale during stimulation was observed in 67% of the patients and 29% of the patients reported a moderated reduction in pain. A relevant reduction in pain medication was observed in 70% of the patients. No accompanying medication was necessary in half of the patients treated. Almost all the patients reported an improvement in their general health situation.

The goal of a further clinical study was to test if the P-STIM<sup>®</sup> concept could be used to treat lumbago<sup>19,20</sup>. Here, ten patients suffering from chronic pain with a VAS score over 5, despite pain medication, were examined. In six patients there was a pain reduction of 50% and in two patients a reduction of 80% was achieved. Two patients terminated the study because of poor compliance. In 20% of the patients, all analgesic medication was stopped during the treatment with P-STIM<sup>®</sup>. A great improvement in mobility was achieved in all patients.

In conclusion, our study shows stimulation-related, quantifiable and reproducible alterations in cerebral parameters after point-stimulation in two female volunteers. Further studies are necessary in order to verify the results.

## ACKNOWLEDGEMENTS

The authors thank Dr med. Lu Wang for performing the acupuncture and Ms Evamaria Huber (both at the Department of Biomedical Engineering and Research in Anaesthesia and Critical Care, Medical University of Graz) for her support in collecting data and signal analysis. We thank Biegler Medizin Elektronik (Mauerbach, NÖ, Austria) for supplying of both P-STIM<sup>®</sup>-units free of charge.

## REFERENCES

- 1 Strittmatter B, Strittmatter M. Ohrakupunktur und Schmerzgedächtnis—Neue Therapiemöglichkeiten. *Schmerz Akupunktur* 2003; **1**: 7–12
- 2 Litscher G, Schwarz G, Sandner-Kiesling A, et al. Transkranielle Dopplersonographie—Roboter-gesteuerte Sonden zur Quantifizierung des Einflusses der Akupunktur. *Biomed Technik* 1997; **42**: 116–122
- 3 Litscher G, Schwarz G, Sandner-Kiesling A, et al. Effects of acupuncture on the oxygenation of cerebral tissue. *Neurol Res* 1998; **20**/1: 28–32
- 4 Litscher G, Schwarz G, Sandner-Kiesling A, et al. Robotic transcranial Doppler sonography probes and acupuncture. *Intern J Neurosci* 1998; **95**: 1–15
- 5 Litscher G, Wang L, Yang NH, et al. Ultrasound-monitored effects of acupuncture on brain and eye. *Neurol Res* 1999; **21**: 373–377
- 6 Litscher G, Wang L, Yang NH, Schwarz G. Computer-controlled acupuncture<sup>®</sup>. Quantification and separation of specific effects. *Neurol Res* 1999; **21**: 530–534
- 7 Litscher G, Cho ZH, eds. *Computer Controlled Acupuncture<sup>®</sup> (CCA)*, Lengerich Berlin Rom Riga Wien Zagreb: Pabst Science Publishers, 2000
- 8 Litscher G. Spezifische Effekte der Akupunktur im Gehirn. HAI 2000. *J Anästhesie Intensivbeh* 2000; **3**: 128–129
- 9 Litscher G, Wang L. Zerebrale Nahinfrarot-Spektroskopie und Akupunktur—Ergebnisse einer Pilotstudie. *Biomed Technik* 2000; **45**: 215–218
- 10 Litscher G. *High-Tech Akupunktur<sup>®</sup>*. Lengerich Berlin Düsseldorf: Pabst Science Publishers, 2001
- 11 Litscher G. Computer-based objectivation of traditional Chinese-, ear-, and Korean hand acupuncture: Needle-induced changes of regional cerebral blood flow velocity. *Neurol Res* 2002; **24**: 377–380
- 12 Litscher G, Wang L, Huber E. Veränderungen zerebraler nahinfrarot-spektroskopischer Parameter während manueller Akupunktur-nadelstimulation. *Biomed Technik* 2002; **47**: 76–79
- 13 Litscher G. High-Tech Acupuncture<sup>®</sup>—a scientific interdisciplinary website. *Internet J Alternative Med* 2002; <http://www.ispub.com/ostia/index.php?xmlFilePath=journals/ijam/vol1n1/acuweb.xml> [access date May 2004]
- 14 Litscher G, Schikora D. Nahinfrarot-spektroskopische Untersuchungen zur Nadel- und Lasernadelakupunktur. *Akupunktur Theorie und Praxis* 2002; **30**: 136–141
- 15 Litscher G, Schikora D. Near-infrared spectroscopy for objectifying cerebral effects of needle and laserneedle acupuncture. *Spectroscopy* 2002; **16**: 335–342
- 16 Nogjier P. *Praktische Einführung in die Aurikulotherapie*. Lyon: Maisonneuve Verlag, 1978
- 17 Litscher G, Yang NH, Schwarz G, et al. Computerkontrollierte Akupunktur<sup>®</sup>: Eine neue Konstruktion zur simultanen und kontinuierlichen Erfassung der Blutflussgeschwindigkeit in der A. supratrochlearis und A. cerebri media. *Biomed Technik* 1999; **44**: 58–63
- 18 Hoda MR, Lechner W, Grimm K, et al. Pre- and postoperative pain management in a surgery unit: Preliminary results of using miniaturized ear electroacupuncture and perspectives for future clinical investigations. Abstract. *Acta Chirurgia Austriaca* 2000; **32** (Supple.): 162
- 19 Sator-Katzenschlager S, Künnemann M, Balassy C, et al. Mikro-Punktalstimulationsgerät in Verbindung mit integrierten Therapienadeln—Eine neue Behandlungsmethode von Lumbago? 8. Wissenschaftliche Tagung der Österreichischen Schmerzgesellschaft, Bregenz, May 2000
- 20 Sator-Katzenschlager S, Nuhr A, Balassy C, et al. Mikro-Punktalstimulationsgerät in Verbindung mit integrierten Therapienadeln—Eine neue Behandlungsmethode von Lumbago? Abstract, *Der Schmerz* 2000; **14** (Supple.): 1
- 21 Sator-Katzenschlager SM, Széles JC, Scharbert G, et al. Electrical stimulation of auricular acupuncture points is more effective than conventional manual auricular acupuncture in chronic cervical pain: A pilot study. *Anesth Analg* 2003; **97**: 1469–1473