RESEARCH ARTICLE

Violet Laser Acupuncture — Part 5: An Investigation of Different Stimulation Frequencies on Heart Rate and Variability

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Abstract

Violet laser acupuncture was recently described by our research group. Neurochemical studies of acupuncture analgesia revealed that 2- and 100-Hz peripheral stimulation induce differential peptide release from preproenkephalin and preprodynorphin via different neural pathways. The goal of the fifth part of this series was to perform a pilot investigation on the effects of 2- and 100-Hz violet laser acupuncture on heart rate (HR) and its variability (HRV) in 13 healthy volunteers (mean age ± standard deviation: 23.9 ± 1.7 years) using a new non-invasive method. We found a significant difference in mean HR before, during, and after 2- or 100-Hz violet laser acupuncture, and there was a significant difference of the low frequency/ high frequency ratio before, during, and after 2- or 100-Hz violet laser acupuncture. However, we did not observe a significant difference in total HRV before, during, or after treatment. Further studies should be carried out to compare the effects of different violet laser acupuncture frequencies.
1. Introduction

Frequencies are an important aspect of electroacupuncture (EA) research and have been studied at the Neuroscience Research Institute of Peking University under the supervision of Professor Han Ji-Sheng. A significant amount of research was performed on modern acupuncture technologies, which bridge the gap between traditional Chinese medicine (TCM) and Western medicine. Professor Han’s research is well known in Asia and Europe, and he was responsible for introducing many people to the effects of acupuncture, especially EA and the differential effects of various frequencies [1,2].

Violet laser acupuncture was recently described by our research group for the first time. We presented the first four parts of our investigation—reproducible effects on brain circulation (multidirectional transcranial ultrasound Doppler sonography), peripheral microcirculation (laser Doppler flowmetry), temperature distribution (thermal infrared imaging), and human arterial stiffness and wave reflection—in the Journal of Acupuncture and Meridian Studies [3–6].

The goal of this fifth part of the series was to investigate some of the frequencies used and described by Professor Han in EA in noninvasive violet laser acupuncture. The pilot investigations on the effects of different stimulation frequencies of violet laser acupuncture on heart rate (HR) and its variability (HRV) were performed in 13 healthy volunteers at the Medical University of Graz in Europe.

2. Materials and methods

2.1. Violet laser acupuncture

The method of laser needle acupuncture has been described in detail previously [3–6]. Briefly, noninvasive violet optical needles (wavelength, 405 nm; output power, 110 mW; laser needle spot diameter, 500 µm; time, 10 minutes) were fixed onto the skin but not inserted. Measurements were performed using an innovative research system from Laser-needle EG GmbH (Wehrden, Germany). This laser system consisted of 10 semiconductor injection laser diodes. Each single needle can emit a different wavelength, and this system is the first to include five violet laser needles. The technical parameters mentioned are those given by the manufacturer. In the current study, two different frequency modes were used: 2 Hz (pulse duration, 0.25 seconds on, 0.25 seconds off) and 100 Hz (pulse duration, 0.005 seconds on, 0.005 seconds off; thus, the overall energy dose is the same for both frequencies, and is 50% of that during continuous mode stimulation). Due to coupling losses, the output at the tip of the laser needle was approximately 100 mW. Because irradiation lasted 10 minutes (600 seconds), optical power energy density was very high (range: J/cm²) [3–6]. Fig. 1 shows the laser needle system in the high-tech acupuncture laboratory in Graz.

2.2. Monitoring HRV

An HRV Medilog AR12 system (Huntleigh Healthcare, Cardiff, UK and Leupamed GmbH, Graz, Austria) was used for cardiac monitoring. The system is designed for a monitoring period of more than 24 hours. The sampling rate of the recorder is 4096 Hz, which allows for extremely accurate R-wave detection. All raw data are digitally stored on special memory cards that can be read with an appropriate card reader connected to a standard computer. The dimensions of the used HRV recorder are 70 × 100 × 22 mm.

HRV is measured as the percentage change in sequential chamber complexes (RR intervals) in the electrocardiogram (ECG). HRV can be quantified over time by registering percentage changes in RR intervals in the time domain, and changes in the frequency range can be assessed by analyzing ECG power spectra. The parameters used were recommended by the European Society of Cardiology and the North American Society of Pacing and Electrophysiology Task Force [7]. Calculation of ECG power spectra is thought to provide information about the effects of sympathetic and parasympathetic systems on HRV [8,9]. Early work demonstrated that several bands in the HRV spectrum could be interpreted as physiologically relevant markers. Associated mechanisms include thermoregulation, which can be found in the very low frequency band, blood pressure, and respiratory effects [7].

The new ‘Fire of Life’ software analyzes HRV and displays it in a new way to facilitate autonomic nervous system functional assessment. This innovative analysis can help to visualize how the human body reacts to acupuncture. For offline inspection, all ECG raw data can be displayed on a screen. In addition to HR and HRV, the low frequency (LF)/high frequency (HF) ratio was calculated.

2.3. Volunteers

Thirteen healthy volunteers (mean age ± standard deviation [SD]: 23.9 ± 1.7 years; range 22 – 27 years; five females, eight males; height 175.2 ± 7.2 cm; weight 69.4 ± 9.8 kg) were enrolled in our study. None of them was under the influence of centrally active medication, and all were free of neurologic and respiratory disorders. They were informed about the nature of the investigation as far as the study design allowed and provided written informed consent. The study was approved by the local ethics committee.

Participants were lying comfortably on a bed during the investigations (Fig. 2). Three electrodes (Skintact Premier F-55, Leonhard Lang, Innsbruck, Austria) were fixed on the standard positions on the thorax for recording the ECG.
2.4. Acupuncture points

The laser needles were applied to the following acupoints (Figs. 2 and 3):

- Neiguan (PC6)
  Location: as described by the World Health Organization (WHO);
  Stimulation: bilaterally;
  Laser needle fixed on the skin with an adhesive plaster
- Shenmen ear acupoint
  Location: At the lateral third of the triangular fossa in the bifurcating point between superior and inferior crura of antihelix [8];
  Stimulation: bilaterally
  Laser needle contacting the ear skin with the help of a specially constructed holder
- Baihui (GV20)
  Location: as described by the WHO;
  Laser needle in contact with the acupoint with the help of a specially constructed holder.

2.5. Measurement procedure

As depicted in Fig. 3, the volunteers lay on the bed for 10 minutes to achieve steady-state baseline values (a, b). Then, the laser was turned on for 10 minutes (c, d). Stimulation was performed in 2- or 100-Hz frequency mode (in randomized order on the same day with a break of at least 25 minutes between the two measurement sets (a-e). There was a 10-minute control phase after active stimulation (e, f).

2.6. Statistical analysis

Data were analyzed with a one-way repeated measures analysis of variance (ANOVA; SigmaPlot 11.0, Systat Software, Chicago, IL, USA), and the Holm-Sidak method was used for post hoc analysis. The level of significance was defined as \( p < 0.05 \).

3. Results

Fig. 4 shows changes in mean HR during violet laser stimulation at 2 Hz (left) or 100 Hz (right). HR decreased significantly during and after stimulation with both frequencies.

No significant changes were found in total HRV (Fig. 5).

Fig. 6 shows the changes in the LF/HF ratio in the 13 volunteers before, during, and after 2- and 100-Hz laser needle stimulation. There were no valid data for phase b; because we also registered other parameters (data not shown), the handling of the respective devices caused too many disturbances and thus invalidated the LF/HF parameter in this phase. Note the highly significant increase in the LF/HF ratio during and after the 100-Hz stimulation.

4. Discussion

Violet laser acupuncture has been used at the TCM Research Center Graz, and four preliminary scientific studies have been performed. Violet laser acupuncture at the acupoint Dazhui has been shown to increase brain circulation, peripheral circulation, and local temperature [3,5]. Although stimulation of the acupoint Baihui has not been demonstrated to significantly affect HR or mean arterial blood pressure [6], earlier studies only applied continuous violet laser stimulation. A search with the key words 'Violet laser acupuncture and frequency' in the scientific database PubMed (www.pubmed.gov) determined that as of April 26, 2012, there were no publications on this specific topic.

Therefore, the current study is the first comparison of the effects of different frequencies of violet laser acupuncture on HR, HRV, and LF/HF parameters. There were no significant HRV differences when comparing data from before, during, and after 2- or 100-Hz violet laser acupuncture. However, the mean HR differences before, during, and after 2- or 100-Hz violet laser acupuncture were significant. We also observed significant differences in LF/HF before, during, and after 2-Hz or 100-Hz violet laser acupuncture.

Important parameters of EA include frequency, intensity, and duration. Of these, frequency seems to be the most critical element. Frequencies of 2 and 100 Hz are commonly used as the standard settings for LF and HF EA, respectively [9]. In acupuncture analgesia, 2-Hz EA had greater and more prolonged analgesic effects on mechanical allodynia and thermal hyperalgesia than 100-Hz EA in
a rat model of neuropathic pain [10]. Neurochemical studies in acupuncture analgesia revealed that 2- and 100-Hz peripheral stimulation induce differential peptide release from preproenkephalin and preprodynorphin. Specifically, 2-Hz EA accelerates enkephalin, beta-endorphin, and endomorphin release, whereas 100-Hz EA selectively increases dynorphin release [11–13]. It has been suggested that varying therapeutic effects induced by different frequencies of EA are mediated via distinct neural pathways [2,14]. In the current study, the HR decrease induced by 2-Hz violet laser acupuncture was earlier, greater, and more prolonged than that at 100 Hz. These results suggest a possible correlation between acupuncture analgesia and violet laser acupuncture-induced HR changes that should be explored in future studies.

HR and HRV are important parameters of autonomic nervous system regulation. In recent years, computer analysis of HR and HRV has allowed for the identification of specific brain-modulated autonomic influences [15–18]. In the current study, we found that adult HRs significantly
decreased during violet laser acupuncture at both 2 and 100 Hz, which is in accordance with what we observed during continuous violet laser acupuncture [19]. We also found significant changes in the LF/HF ratio, which is also in accordance with previously published results [19]. Notably, the previous study only included the Neiguan acupoint, whereas we stimulated three acupoints—Baihui, Shenmen (Extra), and Neiguan. Perhaps the high significance was the result of stimulating different acupoints simultaneously.

5. Conclusion

Based on the results of the fifth part of the study, we conclude that frequency is an important factor in violet laser acupuncture. Both frequencies induced changes in patients' HRs and LF/HF ratios, but we did not observe a change in HRV induced by violet laser acupuncture at either frequency. Further studies should be carried to compare additional violet laser acupuncture frequencies.

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References