

Blue 405 nm laser light mediates heart rate – investigations at the acupoint Neiguan (Pe.6) in Chinese adults

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Abstract

Background: In previous studies, we showed that laser needle acupuncture with red and infrared light has specific effects on bio-signals of the brain and heart. **Aims:** In this publication we report the effect of blue laser light on heart rate and heart rate variability (HRV) before, during and after acupuncture at the acupoint Neiguan (Pe.6) in Chinese adults. These are the first data published concerning heart rate and HRV, obtained with blue laser acupuncture equipment. **Patients and Methods:** The investigations were carried out in 13 healthy Chinese volunteers with a mean age of 31.2 ± 7.5 years within a randomized, controlled study. Stimulation was performed with painless blue laser light (wavelength: 405 nm; activation: 10 minutes) bilaterally at Pe.6. In a second session, for control reasons the laser was not activated. **Results** Heart rate showed a significant ($p=0.008$) decrease during blue laser light stimulation. In contrast, no significant changes were found when the laser was deactivated. The evaluation parameter LF/HF ratio (low frequency/high frequency ratio) from the HRV spectral analysis showed a very slight increase during stimulation, however it was not significant. **Conclusions:** Our main conclusion is that continuous blue laser light stimulation on Neiguan significantly reduces heart rate of Chinese adults.

Keywords: Blue laser, acupuncture, laser needle, Neiguan, heart rate, heart rate variability, autonomic nervous system, Traditional Chinese Medicine.

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Introduction

Traditional Chinese Medicine (TCM) has made many important contributions to the medicine of the world in general. In China and neighbouring countries and regions it has served as the basis of medical knowledge for thousands of years. In recent years, TCM and especially acupuncture has also enjoyed a growing popularity in the Western world. In both Europe and the United States there are numerous practitioners of acupuncture. However, scientific research of acupuncture using high-tech methods

has only been performed intensively during the last decade. The Research Unit of Biomedical Engineering in Anaesthesia and Intensive Care Medicine and now the TCM Research Center Graz at the Medical University has been dealing with the demystification of acupuncture using non-invasive methods [1-10].

The ability to heal illnesses and relieve pain with light is a fascinating vision. Scientists agree that the 21st century will be the century of photons, as the past 20th century was

that of the electrons. In this context, new acupuncture stimulation methods like painless laser needles are a characteristic tool for the innovation in acupuncture research [11]. For the first time, these so-called “needles of light” allow painless and highly effective acupuncture treatment according to traditional rules. Up to now, investigations in the field of TCM were performed using red and infrared laser light [12-16]. Within this contribution, a new acupuncture stimulation method – the blue laser – is used. In medicine in general blue lasers are utilized in just a few special areas [17-19], because it is a new and still expensive invention [20]. In acupuncture research in particular, blue laser was applied only in one scientific investigation until now, which is published by our research group in September 2009 [21].

As mentioned before, there are different methods for bioengineering assessment of peripheral and cerebral effects of acupuncture [1-10]. Heart rate (HR) and heart rate variability (HRV) are important physiological parameters. HRV refers to the amount of heart rate fluctuation in the mean heart rate and reflects the modulation of cardiac function by autonomic and other functional regulatory systems [22].

The aim of this research article is to describe for the first time the possible influence of blue laser acupuncture at the acupoint Neiguan (Pe.6) on HR and HRV in Chinese adults.

Materials and Methods

Chinese volunteers

The investigations were carried out in 13 healthy Chinese volunteers with a mean age \pm SD of 31.2 ± 7.5 years (range 25-50 years; height 166.0 ± 4.7 cm, weight 60.2 ± 10.3 kg; 6 f, 7 m). None of the volunteers was under the influence of medications. All persons were free of neurologic or cardiologic disorders. They were informed about the nature of the investigation as far as the study design allowed and were paid for their participation. The study was approved by the local ethics committee, and all persons gave written informed consent.



Fig. 1 High-tech acupuncture with blue laser needles at the acupoint

Neiguan (Pe.6) in Chinese adults at the Medical University of Graz (with permission of the volunteers).

Stimulation, recording and evaluation parameters

Blue laser needle acupuncture is a new optical method for stimulating different acupoints continuously and simultaneously. Red and infrared painless laser needles were developed in 2002 [11, 14-16]. Blue laser light with a wavelength of 405 nm, an output power of 110 mW and a diameter of 500 μ m is used in this investigation. These blue laser needles are special light conductors which are placed vertically at the skin and trigger painless stimulation at the acupoint (Fig. 1).

Acupuncture was performed at the acupoint Neiguan (Pe.6) on both arms (comp. Fig. 1). This point is located between the tendons m. palmaris longus and m. flexor carpi radialis, 2 Cun proximal to the transverse crease of the wrist. The Cun is a relative body measure; therefore an exact translation into centimetres is not possible. One cun is the distance between the transverse creases of the interphalangeal bone of the middle finger when the patient's finger is slightly flexed. The breadth of the distal phalanx of the thumb is also equal to 1 cun [23]. In most adults, one cun will amount to 2.5 – 3.5 cm. The acupoint Neiguan is indicated in heart disorders and disorders of the chest area, especially angina pectoris [23]. The laser needles were applied and fixed to the skin with a special adhesive tape after disinfection of the skin at the acupoint with alcohol. During testing, the volunteers were positioned relaxed on a bed. In two different tests, the blue laser needles were once applied and activated for 10 minutes, or remained deactivated in an identical procedure (placebo). Which test procedure was performed first was selected at random (Fig. 2). Each volunteer was tested with activated as well as deactivated blue laser needles, whereby the volunteers were not informed about the mode being used. The resting period between both tests was at least 10 minutes. The acupuncture and placebo sessions took place between 9 a.m. and 2 p.m. in our laboratory at the Medical University of Graz.

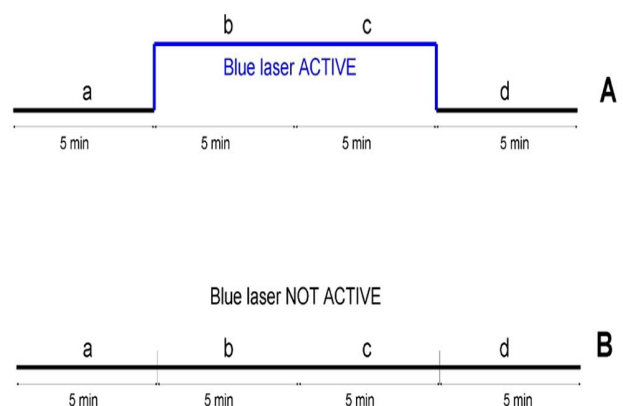


Fig. 2 Stimulation procedure and different measuring phases (a: before, b & c: during, d: after stimulation). A: Scheme including blue laser active; B: all phases (a-d) laser not active (placebo).

The test persons were monitored using an

electrocardiographic recorder (Medilog® AR12; Huntleigh Healthcare, Cardiff, UK) which was partially developed in Austria. The electrocardiogram (ECG) was recorded with a sampling rate of 4096 Hz and a frequency range of 0.1 – 1,900 Hz. This digitizing at a very high sampling rate and resolution enables high accuracy for R-wave peak detection and therefore increased accuracy for RR-interval analysis. The data (raw ECG) is stored digitally on a memory card. After removing the memory card, the data can be read by an appropriate card reader. The dimensions of the instrument are 70 x 100 x 22 mm, and the weight without batteries is about 75 g. The R-peak time resolution is 244 μ s and the P and T time resolution 1953 μ s. Three ECG electrodes are necessary. Using medilog Darwin HRV software it is possible to check the whole measurements visually and computer-assisted. Spectral analysis allows the classification of variability in different spectral ranges, which represent biological rhythms that seem to be distinguishable among the following:

- * Respiratory sinus arrhythmia (approx. 0.15 – 0.4 Hz); centrally nervous respiratory impulses and interaction with pulmonary afferents (high frequency (HF-) band);
- * The so-called “10-second rhythm” (approx. 0.04 – 0.15 Hz); natural rhythm of cardiovascularly active neurons in the lower brainstem (circulatory center and its modulation by feedback with natural vasomotoric rhythms via baroreceptor feedback). Analogous blood pressure waves (blood pressure waves of third order) prove the connection (low frequency (LF-) band);
- * Longer wave HRV-rhythms (approx. < 0.04 Hz); effects from the renin angiotensinsystem or temperature regulation as well as metabolic processes.

A division of HF (high frequency) and LF (low frequency) bands was used to calculate the LF/HF ratio (comp. Fig. 3).

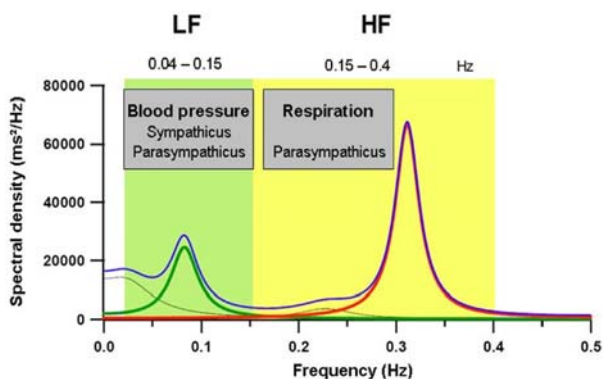


Fig. 3 Spectral analysis of heart rate variability (HRV); LF: low frequency band; HF: high frequency band.

In addition, with the new Fire of Life™ software the HRV

is analysed and displayed in a new way to help judge the function of the autonomic nervous system.

Statistical analysis

The results are shown graphically with box plot illustrations (Sigma Plot 11.0, Jandel Scientific Corp., Erkrath, Germany). Paired t-test was used to evaluate possible laser-specific effects before, during and after acupuncture. Significance was defined with $p \leq 0.05$.

Results

The first investigations of blue laser stimulation yielded very interesting results. All persons felt the stimulation performed on the acupoint Neiguan similar to deQi-sensation. In contrast, using red or infrared laser stimulation, only 5 – 10 % of the subjects reported immediate deQi-sensation [21].

Figure 4 summarizes the results of HR from all 13 volunteers. Significant differences were found during active blue laser stimulation (Fig. 4, left panel). Heart rate decreased during the two phases of stimulation (b, c; comp. Fig. 2) in twelve of 13 Chinese volunteers during active laser stimulation. Even after stimulation, HR values were still markedly lower (n.s.) compared to baseline values. In contrast, during the session with the deactivated laser, seven persons showed a slight increase and six a slight decrease of HR in phase b (comp. Fig. 4). No significant changes occurred during and after the placebo measurement (laser not active; Fig. 4, right panel).

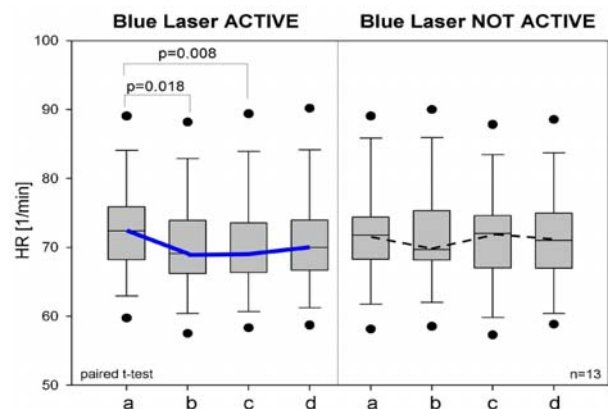


Fig. 4 Box-plot illustrations of heart rate (HR) under the two conditions blue laser active (left panel) and blue laser not active (right panel). Note the significant decrease in HR during blue laser stimulation at the acupoint Neiguan. The horizontal line in the box shows where the median is situated. The ends of the box define the 25th and 75th percentile; error bars show the 10th and 90th percentile. The different measurement phases are marked with a – d (compare Fig. 2).

An example of the ‘Fire of Life’ analysis of HRV is demonstrated in Fig. 5. The graphic shows sympathetic and vagal activity. The three frequency ranges described above (Stimulation, recording and evaluation parameters) can be seen clearly. It is interesting that in this 25-year-old female during and after blue laser stimulation the activity increases in the frequency band representing the respiratory sinus arrhythmia (~0.3 Hz). This, however, was

not the case in all volunteers (comp. Fig. 6).

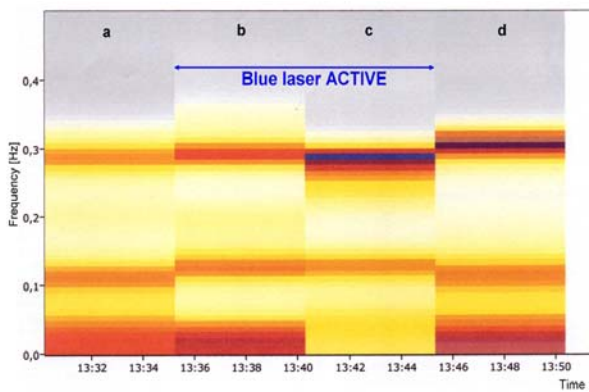


Fig. 5 “Fire of Life” analysis of heart rate variability. Four 5-min-intervals (a – d; comp. Fig. 2) are presented. Note that during and after blue laser stimulation the activity within the frequency band of the respiratory sinus arrhythmia (~ 0.3 Hz) increases. The influence of the blood pressure waves can be seen at the frequency range of about 0.1 Hz.

Figure 6 shows the LF/HF ratio in all 13 volunteers. No significant changes were found in this evaluation.

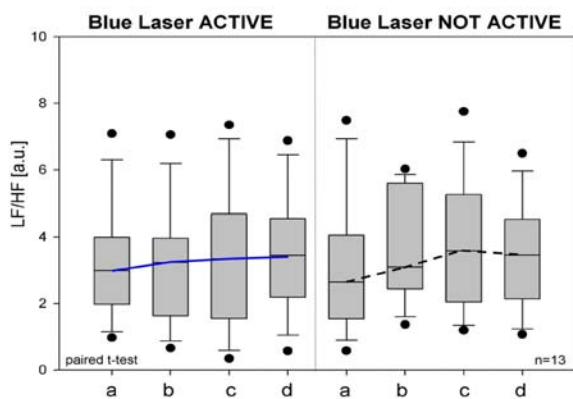


Fig. 6 Box-plot illustration of the evaluation parameter LF/HF-ratio in arbitrary units (a.u.) during the two different acupuncture sessions (blue laser active and blue laser not active). No significant changes are seen. For further explanations see Figs. 2 and 4.

Discussion

Modernization of traditional Chinese acupuncture using different computer-based high-tech methods is an important step in bridging Eastern and Western medicine [1-10, 21]. Within the last years innovative acupuncture stimulation methods as well as measurement procedures have been developed worldwide. This publication focuses on a totally new acupuncture stimulation method – called the blue laser acupuncture. Until now important areas of application of the blue laser include telecommunication (blue-ray disc), information technology, electronic equipment, displays and laser TV. In the field of medical research, especially in acupuncture, the blue laser has only been used in one scientific study [21].

A new invention of Shuji Nakamura [20] enabled the development of small, convenient blue and violet lasers which had not been available before. Our acupuncture

laser equipment operates at a wavelength of 405 nanometres. It is worth noticing that this wavelength is not in fact blue, but appears to the eye as violet, a colour for which the human eye has a very limited sensitivity.

Although the blue laser does not have the same penetration depth in human skin as the red and infrared laser (blue: approximately 2 mm vs. red/infrared: 2 – 3 cm [11, 21, 24], the evoked deQi-sensation, which is a prerequisite for effective acupuncture stimulation, may warrant the scientific investigation of blue laser stimulation in acupuncture [21]. As mentioned, according to TCM one must first obtain deQi for acupuncture to be effective. Patients and volunteers describe this feeling as heaviness or like an electrical current running along the treated meridians, which are “channels” in TCM. DeQi sensation is also achieved with blue laser light of sufficient intensity (405 nm, 110 mW, 500 μ m). It is important to understand that laser light may be concentrated to achieve high intensities yet still be given at relatively low average output powers. This is accomplished by reducing the area of the laser beam. If red (685 nm) or infrared (785 nm) lasers are used, the patients normally do not notice when the laser is started. So in the beginning of the treatment they also do not feel any deQi sensation. Several minutes later (5 – 10 min) many patients report a pleasant warm and sometimes vibrating feeling in some treated areas [25]. On the contrary, using the blue laser acupuncture at Neiguan, the Chinese volunteers described that the blue laser induced feelings similar to an “ant-like bite” followed by a feeling similar to a slight electrical current which is similar to deQi evoked by a metal needle. In our present study only Chinese people were investigated in order to get results from volunteers who already had extensive experience with needle acupuncture. In a following study we will compare the data with European volunteers with and without any experience concerning acupuncture.

The acupoint Neiguan is located near to the median nerve [26]. Already in 1984, Walker and Akhanjee reported that irradiation of the skin overlying the median nerve at the wrist in humans with a low-power (1 mW; 632.5 nm) helium-neon laser produced a somatosensory evoked potential obtained at Erb’s point. Prolonged exposure to laser light (30 min, 3.1 Hz) resulted in a large (10 – 90 %) decrease in the amplitude of the evoked potential. Since that kind of laser produces no detectable thermal change, the authors concluded that photochemical reactions alter neuronal activity. In a previous study we found that blue laser stimulation increases temperature (mean ~ 1.5 °C) and microcirculation (mean ~ 20 %) at the acupoint Hegu (LI.4) significantly and immediately (1 min) after stimulation onset [21]. The main interesting finding of this publication is that HR decreases significantly within an interval of 5 min after blue laser stimulation onset.

As described in the section “Materials and Methods”, the acupoint is indicated in heart disorders. Acupuncture at the Neiguan point has also been shown to lessen nausea and vomiting which are related to vagal modulation. Therefore

the investigation of HRV is also of special importance. Other authors have already shown that needle acupuncture at the Pe.6 point can increase vagal modulation of healthy Asian volunteers [28].

HRV is measured as the perceptual change in sequential chamber complexes (RR-intervals) in the ECG, which is controlled by the blood pressure control system, influenced by the hypothalamus, and, in particular, controlled by the vagal cardiovascular center in the lower brainstem [7].

HRV can be quantified in the frequency range by analysis of ECG-power spectra (comp. Fig. 3). Publications concerning acupuncture and HRV by scientists from China, Austria, Germany, Italy, Russia, the USA and Taiwan can be found in a recently published review paper [7].

Although the results from pilot studies regarding HRV and acupuncture at Neiguan performed by Litscher et al. [29] using electrical stimulation show that spectral-analytical assessment of HRV shows marked differences, in particular in different frequency bands, and indicates an increased influence of respiratory components on the entire HRV during and after conditions of acupuncture, in this study we did not find significant changes in the HRV parameter LF/HF-ratio in all persons. Further investigations whether the stimulus modality (manual needle, electrical, laser) plays an important role are also in progress. It should also be mentioned here that stimulation at other acupoints like Yintang (Ex.1) resulted in significant changes in LF/HF-ratio and other parameters [30, 31].

Conclusions

The following conclusions can be drawn from the results of this study in which 13 Chinese healthy adults were examined:

1. Blue laser needle acupuncture (405 nm, 110 mW, 500 μ m) at the acupoint Neiguan (Pe.6) induces an immediate effect which is similar to a strong deQi sensation.
2. Heart rate is significantly reduced during continuous blue laser stimulation at point Neiguan.
3. Heart rate did not change significantly during and after stimulation with deactivated laser stimulation.

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