Hemodynamic Effect of Laser Therapy in Spontaneously Hypertensive Rats

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Abstract

Systemic arterial hypertension (SAH) is considered to be the greatest risk factor for the development of neuro-cardiovascular pathologies, thus constituting a severe Public Health issue in the world.

The Low-Level Laser Therapy (LLLT), or laser therapy, activates components of the cellular structure, therefore converting luminous energy into photochemical energy and leading to biophysical and biochemical reactions in the mitochondrial respiratory chain. The LLLT promotes cellular and tissue photobiomodulation by means of changes in metabolism, leading to molecular, cellular and systemic changes.

The objective of this study was to analyze the action of low-level laser in the hemodynamic modulation of spontaneously hypertensive rats, in the long term. Animals (n = 16) were randomly divided into the Laser Group (n = 8), which received three weekly LLLT irradiations for seven weeks, and into the Sham Group (n = 8), which received three weekly simulations of laser for seven weeks, accounting for 21 applications in each group. After seven weeks, animals were cannulated by the implantation of a catheter in the left carotid artery. On the following day, the systemic arterial pressure was recorded. The Laser Group showed reduced levels of mean blood pressure, with statistically significant reduction (169 ± 4 mmHg* vs. 182 ± 4 mmHg from the Sham Group) and reduced levels of diastolic pressure (143 ± 4 mmHg* vs. 157 ± 3 mmHg from the Sham Group), revealing a 13 and 14 mmHg decrease, respectively. Besides, there was a concomitant important decline in heart rate (312 ± 14 bpm vs. 361 ± 13 bpm from the Sham Group). Therefore, laser therapy was able to produce hemodynamic changes, thus reducing pressure levels in spontaneously hypertensive rats.

Keywords

Low-Level Laser Therapy (LLLT); Experimental Laser Therapy; Hypertension; Hemodynamic Changes.

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Introduction

Hypertension is the *causa mortis* of 9.5 million people around the world[1], constituting a major Public Health issue.

The LLLT, or laser therapy, is able to induce a photobiological response inside the cells, activating the production of Adenosine Triphosphate (ATP), Nitric Oxide (NO) and Reactive Oxygen Species (ROS); it also changes sodium-potassium pumps and calcium channels also facilitate membrane permeability[2].

According to Chavantes and Tomimura[3], laser therapy reduces the inflammatory and edematous process, and it also changes the micro and macrovascular response, assisting in tissue repair and enabling analgesia. LLLT has proven to be an efficient, non-invasive, low-cost and safe tool.

A pioneer experimental work[4] analyzed the acute short term actions of LLLT (only three applications) on Systemic Blood Pressure (SBP) in obese and old Wistar rats. The results indicated that LLLT was able to significantly decrease pressure levels, thus revealing cardiovascular protection, which guided the study proposed in this paper.

Therefore, the objective of this study was to evaluate the long term effects of LLLT on the hemodynamic response of Spontaneously Hypertensive Rats (SHR), by assessing Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Mean Blood Pressure (MBP) and Heart Rate (HR).

Method

A prospective, controlled experimental study with 16 male SHR, which were randomly divided into two groups (n = 8): Sham Group and Laser Group. Three weekly LLLT applications were conducted on alternate days, for 7 weeks, accounting for 21 applications in the Laser group. In the Sham Group, the same protocol was implemented, however, the equipment was turned off.

The sample size and the method were based on studies found in literature, assessing hemodynamic changes and physical condition in SHR animals[5,6].

The laser diode (MMOptics) was transcutaneously applied on the rats' tails, as demonstrated in figures 1 and 2, with the following parameters: wavelength (λ) = 780 nm, flow = 30 J/cm^2, power = 40 mW, spot size = 0.04cm^2 and irradiance = 1W/cm^2, accounting for 90 seconds.

After seven weeks, all animals were anesthetized and cannulated by a catheter implantation in the left carotid artery. After the implantation, they were passed

*The result showed statistically significant difference for the laser group subcutaneously and exteriorized in the cervical dorsal region. After the animal had woken up, after 24 hours, the arterial cannula was attached to an electromagnetic transducer (Blood Pressure XDCR, Kent© Scientific, Litchfield, CT, USA) and to the pre-amplifier (Stemtech BPMT-2, Quintron Instrument© Inc, Milwaukee, USA). Signs of Blood Pressure (BP) were digitally recorded for 30 minutes, by means of a data acquisition system (CODAS, 1Kz, Dataq Instruments, Akron, OH, USA). This enabled the analysis of pressure pulse, beat by beat, with sampling frequency of 2,000 Hz per channel, for the study of SBP, DBP, MBP and HR. HR values were derived from the pulse signal of BP[7].

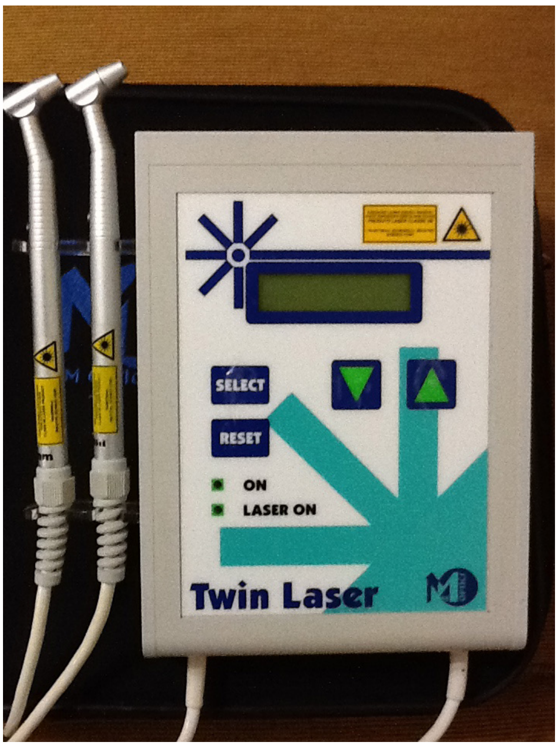

Figure 1 – *Laser diode 780 nm (MMOptics, São Carlos, SP, Brazil).*

Statistical analyses

Values are presented as means ± standard deviations of means. HR, MBP, SBP and DBP were compared between the Sham and the Laser Groups. After the evaluation of distributions by the Kolgomorov normality test, the Student's t-test was used to verify the differences between normal distributions. The adopted statistical software was the GraphPad InStat. Significance level was established as $p < 0.05$.

Results

The Laser Group showed reduction in relation to the Sham Group in the following values: MBP (169 ± 4 mmHg* vs. 182 ± 4 mmHg from the Sham Group) and DBP (143 ± 4 mmHg* vs. 157 ± 3 mmHg from the Sham Group), presenting statistically significant differences. The SBP value (196 ± 5 mmHg vs. 207 ± 4 mmHg from the Sham Group) revealed no differences, as demonstrated in Table 1.

With regard to HR at rest, there was significant decline in heart beats in the Laser Group (Figure 3) when compared to the Sham Group (312 ± 14* bpm vs. 361 ± 13 bpm in the Sham Group).

Discussion

Nowadays, SAH is one of the most prevalent *causa mortis*. Therapeutic strategies that aim at the reduction of SBP are considered to be important.

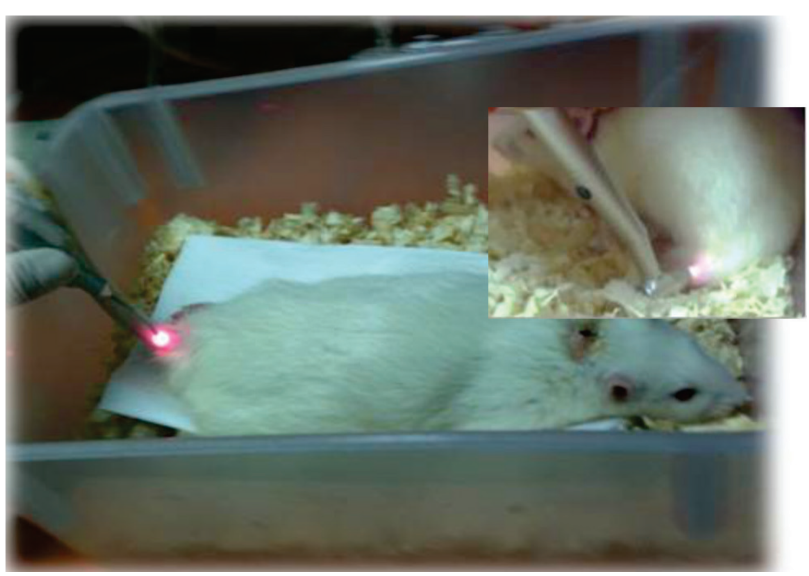

Figure 2 – *Place of irradiation: dorsal tail.*

Nowadays, LLLT is a relevant instrument in the therapeutic arsenal of numberless health fields, being able to modulate the genic expression of chemokines, to change cytokines and NO synthetic inducers. These changes may have important therapeutic relevance in vascular inflammatory processes[8].

The endothelial system plays an essential role to control muscular tonus, responding to dynamic changes in blood flow (shear stress). Regular physical activities are able to stimulate vasodilating factors, thus stimulating the liberation of factors such as NO and the hyperpolarizing factor derived from the endothelium, thus reducing BP levels[9].

In an *in* vitro experiment, Ricci[10] demonstrated that endothelial cells submitted to nutritional stress effectively respond to LLLT irradiation, reorganizing actin filaments in the cytoskeleton, associated with endothelial/cellular proliferation.

A study involving the physical conditioning of SHR demonstrated pressure reduction post-physical training, which led to an important HR decline and, consequently, to decreasing cardiac output[11].

Our experiment observed that HR decreased relevantly in the Laser Group in relation to the Sham group (312 ± 14 bpm

Table 1 – Hemodynamic parameters assessed at rest in the Laser and Sham groups

Parameters	Group	
	Laser	Sham
DBP (mmHg)	143 ± 4*	157 ± 3
SBP (mmHg)	196 ± 5	207 ± 4
MBP (mmHg)	169 ± 4*	182 ± 4
HR (bpm)	312 ± 14*	361 ± 14

*Data expressed by mean ± standard error. * p < 0.05.*
DBP: diastolic blood pressure; SBP: systolic blood pressure; MBP: mean blood pressure; HR: heart rate.

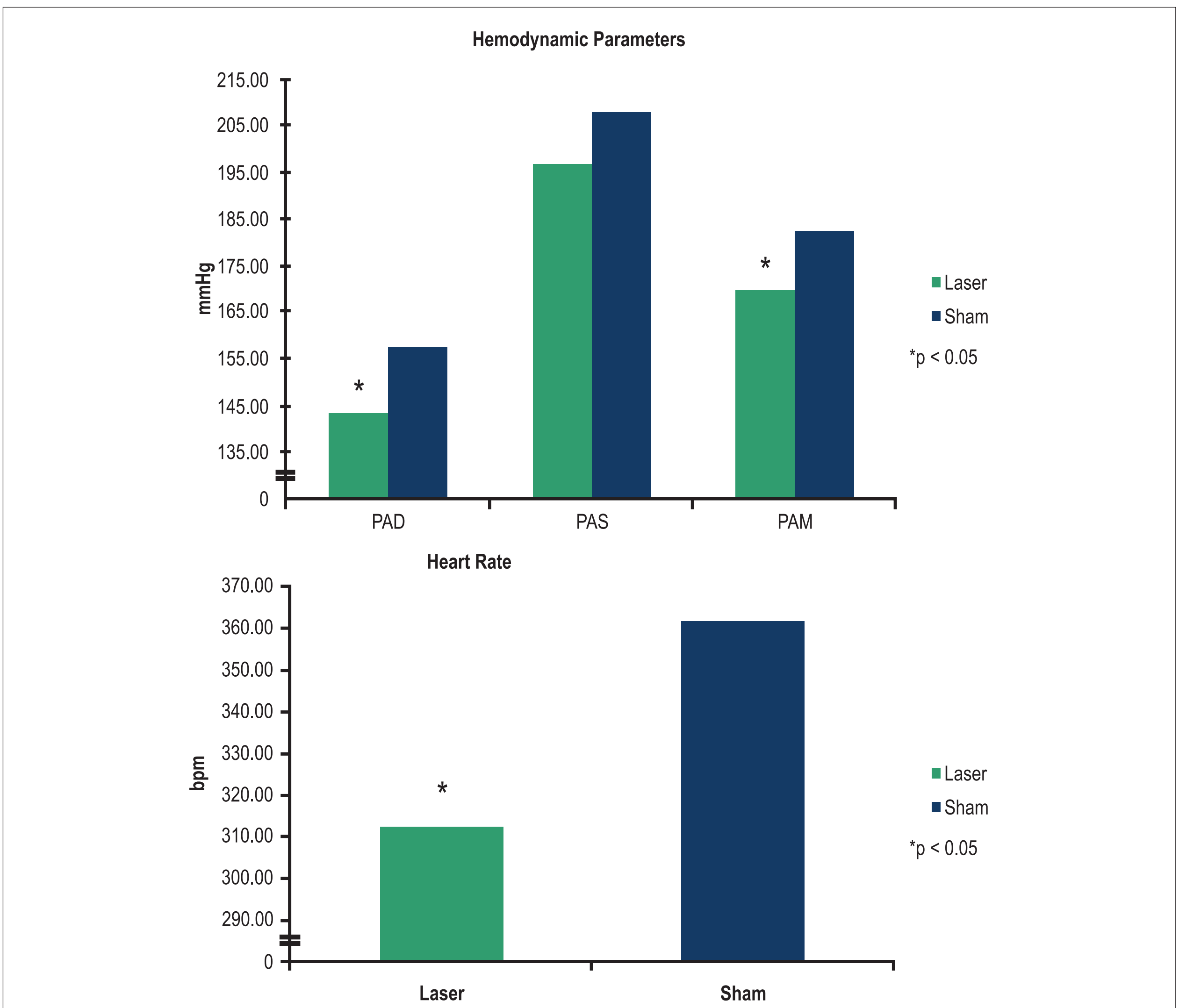

Figure 3 – *Diastolic Blood Pressure (DBP), Systolic Blood Pressure (SBP), mean blood pressure (MBP) and heart rate (HR) of Laser and Sham Groups. * p < 0.05.*

vs. 361 ± 13 bpm), which shows this is one of the possible mechanisms that are able to decrease cardiac output, and, consequently, SAH.

Sanches et al[5], in another experiment with oophorectomized hypertensive female rats (during menopause), used physical training for 8 weeks and demonstrated that physical exercise decreased levels of DBP, SBP, MBP and HR when compared to sedentary hypertensive female rats.

Our study showed expressive decline after LLLT irradiation in the long term, with regard to baseline SHR pressure levels. Both the levels of DBP and MBP were reduced post laser therapy (7 weeks), with statistically significant differences between groups. There are other ongoing experiments in order to understand the mechanisms involved in SAH *versus* LLLT.

Conclusion

Laser therapy applied on spontaneously hypertensive rats in the long term resulted in reduced pressure levels, therefore modulating, expressively, the hemodynamic response among hypertensive rats.

Author contributions

Conception and design of the research: Tomimura S, Sanches IC, Chavantes MC; Acquisition of data: Tomimura S, Silva BPA, Canal M, Conti FF; Analysis and interpretation of the data: Tomimura S, Sanches IC, Conti FF, De Angelis K, Chavantes MC; Statistical analysis: Tomimura S, Sanches IC; Writing of the manuscript: Tomimura S; Critical revision of the manuscript for intellectual content: Sanches IC, Consolim-Colombo F, De Angelis K, Chavantes MC.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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