

Evaluation of Low-Intensity Laser External Radiotherapy through Thermal Texture Mapping (TTM) Technology

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Abstract: Objective: To evaluate the curative effects of Low-Intensity Laser External Radiotherapy through Thermal Texture Mapping (TTM) Technology. Methods: The influences of 30min nasal cavity irradiation of semiconductor laser (650nm, 5mW, continuous wave) on microcirculation were investigated through TTM. At the same time, with the aid of TTM, the influences of the irradiation on the whole body thermal balances and the functions of the liver and kidney were also studied. Altogether, 32 cases of microcirculation depression were investigated. Results: After 30min nasal cavity irradiation, the total efficiency of microcirculation reached 100%. The effective ratio kept 96.9% 30 minutes later but the effect almost disappeared completely 150 minutes after the irradiation. No ill influence on the whole body thermal balance or metabolic functions of liver and kidney was found. Conclusions: Low-Intensity Laser External Radiotherapy was a promising therapy to improve microcirculation. TTM was the ideal evaluation technology promoting this therapy.

Keywords: External radiotherapy, low-intensity laser, microcirculation, thermal imaging, thermal texture mapping (TTM), thermography.

I. INTRODUCTION

Low-intensity laser external radiotherapy is a rising physiotherapy developed from intravenous low level laser irradiation (ILLI) which can improve blood circulation and has certain effect on cardiovascular and cerebrovascular diseases [1-3]. With the advantage of being non-invasive, convenient and safe, low-intensity laser external radiotherapy has been given more and more attention [4]. It is of great importance to seek suitable clinical evaluation methods for the development of this therapy as a safe and effective dose and power of laser and the suitable irradiation positions of the body for different diseases still require study. TTM is a new evaluation technology mainly based on functional medical imaging technique [5-7]. Studies have shown that TTM has the advantages of being sensitive and audio-visual in clinical examination of microcirculation depression [8]. We have attempted to evaluate low-intensity laser external radiotherapy through TTM. With the aid of TTM we observed the effects on microcirculation. At the same time, we also wish to observe its influence on the body's thermal balance and the metabolic functions of the liver and kidney.

II. METHODOLOGY

A. Subjects

Thirty-two cases including 12 male and 20 female were studied. The subjects were in sub-health conditions and aged from 18 to 58. Thirty volunteers had also been studied as the control group.

B. Instruments

Semiconductor laser: 650nm, 5mW \pm 10% continuous wave.

TTM evaluation system: TSI-21M, made by bioyear group. Temperature sensitivity: 0.05°C.

C. Method and steps

1) *Condition:* room temperature 20-23°C, air humidity \leq 75%. Keep away from the influence of medicine, food, exercise and mood. Be aware to keep the temperature stable during the test as the microcirculation is sensible to temperature.

2) *Irradiation position and dose:* nasal cavity, 5mW continuous wave for 30min.

3) *Steps:* TTM examinations were performed before the laser irradiation, immediate after the irradiation, 30 min and 150 min after the irradiation. The 30 subjects in the control group were examined by TTM twice with 30 min intervals without the laser irradiation.

D. Evaluation index (Referring to [9])

1) The difference in thermal radiation between the middle part and the fingertip of the left middle finger F_f was the evaluation index of the microcirculation. $\Delta F_f = F_f$ (after irradiation) - F_f (before irradiation). Evaluation standard: $\Delta F_f \leq -0.5$ (Best effective), $-0.5 < \Delta F_f \leq -0.4$ (Better effective), $-0.4 < \Delta F_f \leq -0.3$ (Good effective), $-0.3 < \Delta F_f \leq -0.2$ (Effective), $-0.2 < \Delta F_f < 0.2$ (Non-effective).

2) The index of the entire body's thermal balance included the right-and-left thermal difference of the center of palmar F_p , fossae supraclavicularis major F_s and axillary fossae F_a . The index of the metabolic function of liver and kidney included the relative thermal radiation of the liver F_l and kidney F_k assistant with the right-and-left thermal difference of axillary fossae. The differences of the thermal

radiation before and after the laser irradiation of F_p , F_s , F_a , F_l , F_k were ΔF_p , ΔF_s , ΔF_a , ΔF_l , ΔF_k separately. Evaluation standard: The thermal balance of right-and-left center of palmar was improved: $\Delta F_p \leq -0.2$, the balance was not influenced: $-0.2 < \Delta F_p < 0.2$, ill influence on the balance: $\Delta F_p \geq 0.2$. Analysis of ΔF_s , ΔF_a , ΔF_l , ΔF_k was the same as ΔF_p .

III. RESULTS

A. The effect of low-intensity laser external radiotherapy on microcirculation

Microcirculation of the 30 subjects of the control group was stable in 30min intervals as for all of the subjects $-0.2 < \Delta F_f < 0.2$.

Shown as table I, the 30min rhinal laser irradiation (650nm, 5mW continuous wave) had a satisfying effect on microcirculation. Immediate after the irradiation, the ratio of better and good effective reached 62.5% and the total efficacy reached 100%. The ratio of good effective was 37.5% and the total efficacy was 96.9% 30 minutes later. But the total efficacy dropped to 9.4% 150 minutes after the therapy.

B. The effect of low-intensity laser external radiotherapy on whole body thermal balance and metabolic function of liver and kidney

The thermal balance of the center of palmar was improved by the 30min rhinal laser irradiation (650nm, 5mW continuous wave). As table II shows, the ratio of good effective reached 31.3% and the total efficacy was 96.9% immediate after the irradiation. The total efficacy was 81.3% 30 minutes later. But 150 minutes after the irradiation the total efficacy dropped to 6.3%.

The therapy had little effect on the thermal balance of the fossae supraclavicularis major or axillary fossae. The influence of the therapy on the metabolic functions of the

TABLE I
THE EFFECT OF LOW-INTENSITY LASER EXTERNAL
RADIOTHERAPY ON MICROCIRCULATION

	Immediate after the irradiation		30min after the irradiation		150min after the irradiation	
	Case	Ratio (%)	Case	Ratio (%)	Case	Ratio (%)
Better effective	1	3.1	0	0	0	0
Good effective	19	59.4	12	37.5	0	0
Effective	12	37.5	19	59.4	3	9.4
Non-effective	0	0	1	3.1	29	90.6
Total efficacy	32	100	31	96.9	3	9.4

liver and kidney was also minimal. As shown in table III and table IV, immediate after the irradiation the total efficacy of improvement was 18.8% for fossae supraclavicularis major, 25.0% for axillary fossae, 12.5% for liver and 9.4% for kidney. As no $0.2 \leq \Delta F$ appeared, it is suggested that the therapy had no ill influence on the body's thermal balance and the metabolic functions of the liver and kidney.

TABLE II
THE EFFECT OF LOW-INTENSITY LASER EXTERNAL
RADIOTHERAPY ON THERMAL BALANCE OF THE CENTER OF
PALMAR

	Immediate after the irradiation		30min after the irradiation		150min after the irradiation	
	Case	Ratio (%)	Case	Ratio (%)	Case	Ratio (%)
Good effective	10	31.3	3	9.4	0	0
Effective	21	65.6	23	71.9	2	6.3
Non-effective	1	3.1	6	18.8	30	93.8
Total efficacy	31	96.9	26	81.3	2	6.3

TABLE III
THE EFFECT OF LOW-INTENSITY LASER EXTERNAL
RADIOTHERAPY ON THERMAL BALANCE OF THE FOSSAE
SUPRACLAVICULARIS MAJOR AND AXILLARY FOSSAE

	Immediate after the irradiation		30min after the irradiation		150min after the irradiation	
	Case	Ratio (%)	Case	Ratio (%)	Case	Ratio (%)
Effective ^a	6	18.8	3	9.4	1	3.1
Non-effective ^a	26	81.3	29	90.6	31	96.9
Effective ^b	8	25.0	4	12.5	2	6.3
Non-effective ^b	24	75.0	28	87.5	30	93.8

^aFossae supraclavicularis major ^bAxillary fossae

TABLE IV
THE EFFECT OF LOW-INTENSITY LASER EXTERNAL
RADIOTHERAPY ON THE METABOLISM FUNCTION OF THE
LIVER AND KIDNEY

	Immediate after the irradiation		30min after the irradiation		150min after the irradiation	
	Case	Ratio (%)	Case	Ratio (%)	Case	Ratio (%)
Effective ^a	4	12.5	3	9.4	1	3.1
Non-effective ^a	28	87.5	29	90.6	31	96.9
Effective ^b	3	9.4	2	6.3	2	6.3
Non-effective ^b	29	90.6	30	93.8	30	93.8

^aLiver ^bKidney

IV. DISCUSSION

The investigation has shown that low-intensity laser external radiotherapy (650nm, 5mW, continuous wave) can effectively improve the microcirculation without ill influence on the body's thermal balance or the metabolic functions of liver and kidney. The subjects studied in this investigation were under the age of sixty and without severe diseases. Further study is required on the outcome of elderly persons, patients with severe diseases and the long term effects and safety.

TTM is the ideal evaluation method for the low-intensity laser external radiotherapy. In addition to being audio-visual, sensitive and non-interfered in reflecting the state of microcirculation, it also is capable of quickly and conveniently presenting information about the integral functions of the body. This is the unique power of TTM.

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