Original Article

Optical Transport Properties along the Pericardium Meridian under Different Pressure

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Abstract:

Introduction: This study seeks to discuss the light wave transport characteristics variation along the pericardium Meridian under different pressures.
Methods: We selected 36 healthy students at the school for this study, tied up the desktop blood pressure cuff onto subjects'right proximal arms, fixed the detection probe immovably on the Neiguan (PC6) acupoint and the reference point which was 1cm off the PC6, and collected the light signal along the meridian and non-meridian when the laser irradiate Jianshi(PC5), Ximen(PC4) and the corresponding reference points respectively under pressure of 0, 100, 130 and 160.
Results: The differences in optical transport properties between meridian and non-meridian were significant: under the same pressures(0s, 100s,130s, and 160mmHg), the relative attenuation rate of optical signal at the same distance between meridian and non-meridian were significant($p<0.001$), the optical signal attenuates slower when it transported along meridians; however, there is no significant difference for the relative attenuation rate of optical signal along meridian or non-meridian under different pressures($p>0.05$). Under four different pressure situations, the optical signal at acupoint(PC5) and non-acupoint(NP) along the meridian were significantly different with the corresponding reference points along the non-meridian($P<0.001$); the optical signal on the meridian is stronger than the non-meridian one; the optical signals are strikingly different at acupoints, non-acupoints, and reference points between and 100, 130, and 160mmHg pressures ($P\leq 0.001$); however, no difference was found between 100, 130, and 160mmHg pressures.
Conclusion: The optical signal on the meridian is stronger than the non-meridian. The optical signal attenuates slower when it transported along meridians. The human meridians may be the good pathway for light waves with certain wavelengths. That is to say light waves with certain wavelengths can transport and be blocked along meridian direction, when it irritates the meridians, or acupoints after excluding the influence of human anatomy structure, which verified again the objective existence of meridians transporting and the possibility of blocking from the optical view.
Keywords: optical phenomenon; optical properties; pericardium

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Introduction

The phenomenon of meridian blocking is a distinctive character appearing in the functional regulation of human body. According to the present reports, all of the mechanical blockage, local cooling by ice bag, local injection of natural saline (NS) or novocain can block the meridian. However, mechanical blocking is the earliest, most convenient, and most commonly seen in the research reports (1). Early in Ming Dynasty, the application of pressing therapy to transport qi along meridian had been recorded in Chinese medical works. The earliest description of the meridian blocking phenomena maybe appeared in the Songs of Golden Needles. It records that pressing the front makes qi flow backward, pressing the back makes qi forward (2).

The investigation of the blocking phenomena of propagated sensation along meridian (PSM) started from late 1950's. At that time, Prof. Hu and the anatomy academic section of Qindao Medical College nearly simultaneously discovered that propagated sensation along meridian can be blocked by mechanical pressure for the purpose of proving the pressing and blocking method described by the ancient people, and acupoint injection of natural saline along meridian, respectively. In 1970s and 80's, not a few units gained certain important experimental results by observing the characteristics and law of the phenomena again. In addition, this has been proved by the foreign researcher's investigation. Since 1980, its underlying mechanism has been explored deeply by Prof. Hu and some other scholars at home on the basis of the previous findings (3). The effect of meridian blocking caused by the mechanical pressure during acupuncture not only can be seen in PSM, but also it's still related to PSM and the course of meridian. Therefore, it's called meridian or channel blocking phenomena as a whole. Investigating on the unique phenomena deeply is very important for us to explore the regulatory mechanism of acupuncture and illustrate the essentiality of meridian (4).

Mechanical pressure on the course of meridian of the subjects whether it has PSM or not results in blocking of needling effect (5). For instance, PSM, analgesics, borborygumus, and myoelectric effects can be reduced, or even disappeared by the mechanical pressing on the course of meridian. It is indicated that pressure blocking the acupuncture effect is regulation principle which has universal relevance. Currently, the meridian blocking phenomena can't be explained by the present western medicine knowledge and life science (6,7). After the infrared radiant track along the meridian course (IRRTM) over human body surface was systematically investigated by using the infrared radiation imaging technique, the results demonstrated that it was a normal biological phenomenon appearing in human subjects (8). In recent years, Professor Xie Shusen in Fujian Normal University proposed the concept of "meridian Optics" (9), used tissue photobiology knowledge to research meridians and achieved certain results, which open up a new research direction for the modern study of the meridian phenomenon. Photonics has been applied to investigate the optical characteristics of meridian and meridian shows the unique characteristics on the contrast to the non-meridian line (10). Hence, we are interested in exploring the underling mechanism of the meridian blocking phenomena from the photonics point of view. Blood pressure cuff has been found an appropriate method to block the PSM once the pressure increases up to 160 mmHg (11-13).

Therefore, this study aimed to figure out the optical characteristics of the meridian blocked by pressure for the explanation of underling mechanism of meridian blocking phenomena and the acupuncture regulation. In this study, the optical properties along the pericardium meridian under different pressures were observed to verify the objective existence of optical meridian phenomenon, and explore whether the optical transportation can be blocked.

Methods

Experimental Procedure and Instruments

The detection of optical characteristics of human body meridians can be finished through studying the optical transport properties of light wave along the meridians on surface, and the schematic diagram of the experiment and the measurement setup are shown in Figures 1 and 2, respectively (Fujian Normal University set up the experimental platform for detecting the optical transmission

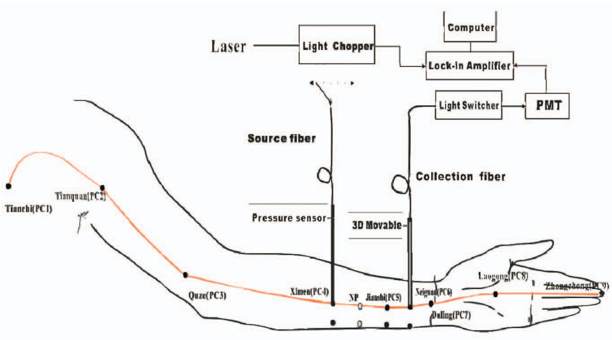

Figure 1. A scheme for light propagating along pericardium meridian and non-meridian directions.

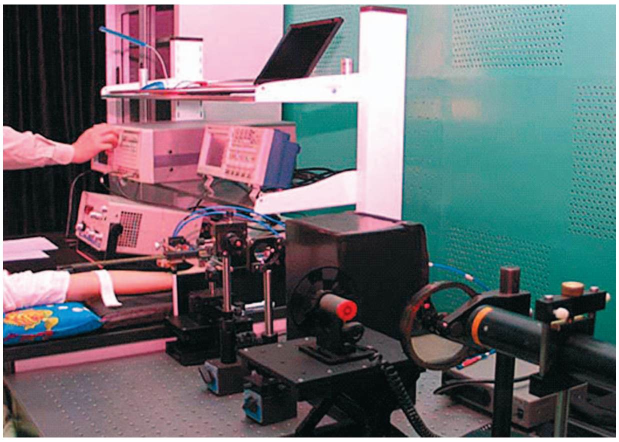

Figure 2. A setup for measuring the optical transport properties of meridian and non-meridian.

characteristics). The 785 nm laser diode (Melles Griot Inc.) was modulated in 10 Hz by an optical chopper (SR540, Stanford Research System). The modulated light was focused into a source fiber with 400 μm core diameter (Ocean Optics), which was put in a small stainless-steel tube with 2 mm diameter. A 2mw laser power was chosen for easy control, which was touched slightly with the skin surface. The intensity of the laser irradiation was 10mW/cm2. The collection fiber was a double-fiber probe containing two 400 μm core diameter fibers (Ocean Optics) which was connected to a PMT (Oriel, USA). The signals from the PMT were delivered to a lock-in amplifier (SR850, Stanford Research System), which was locked to the optical chopper at 10 Hz. The signals could be recorded and displayed in real time. In order to decrease the influence of the remotion of the detection probe, we placed the double fiber probe immovably on the Neiguan (PC6) acupoint and the corresponding reference point in this study, and while testing, we needed only to change over between fiber 1, or fiber 2, and the PMT.

Participants and Methods

Participants

Thirty six healthy volunteers (16 male, 20 female) were recruited from undergraduate and graduate students at Fujian Normal University (mean age ± SD, 24.5 ± 2.3 years). The subjects were healthy, had no history of chronic diseases such as the heart, lung, and kidney diseases, etc, and the primary blood pressures were normal at the time of enrolment. Measured meridian line areas (the pericardium meridian in the study) had no obvious skin scar, or skin diseases. The experimental protocol was approved of by the Key Laboratory of Optoelectronic Science and Technology for Medicine of the Ministry of Education, Fujian Normal University, and Fujian Normal University Hospital. All subjects agreed to participate in the study and provided written informed consent.

The experimental measurements were performed in a dark room with no strong noise and electromagnetic source, and the room temperature was kept at 26.0±1.0°C, the air moisture was kept at 55±10% during the measurements. The meridian and the laser irradiation points on the pericardium meridian and non-meridian were determined and labeled with the help of an acupuncturist before they entered the dark room.

The Experimental Method

Points Selecting Method

Referring to the National Standard of China "Location of Acupoints" (GB12346-90) (14), we adopted the Bone Proportional measurement: The distance from transverse cubital crease to wrist crease includes 12 cuns, and we divided the distance into 12 equal portions each called one "CUN". The cun is the measure unit in acupuncture treatment. This method is to divide the length or width between different parts of the body into a number of equal portions as the standard of acupoints measurement. Hence, it suits all people whether he/she is high, short, fat, thin, young, or old.

Points Selection

1- The points locating steps

Participants entered the lab10 minutes before the test, sat and rested to adapt to the environment and took foundation blood pressure first. Then flat the right arm: firstly, determining Daling (PC7) in the transverse wrist crease and Quze (PC3) in the transverse cubital crease with red oil pen. Secondly, connecting Daling (PC7) and Quze (PC3) for a line which is the superficial passway of the pericardium meridian in the forearm. The length between Daling (PC7) and Quze (PC3) stands for 12 cun, which then makes 12 equal portions, one cun per portion.

Daling (PC7): in the depression in the middle of the transverse crease of the wrist, between the tendons of m. palmris longus and m. flexor carpi radialis.

Quze (PC3): on the transverse cubital crease, at the ulnar side of the tendon of m. biceps brachii.

Neiguan (PC6):2 cuns above the transverse crease of the wrist, between the tendons of m. palmris longus and m. flexor carpi radialis.

Jianshi(PC5): 3cuns above the transverse crease of the wrist, between the tendons of m.palmris longus and m.flexor carpi radialis.

Ximen(PC4): 5cuns above the transverse crease of the wrist. On the line connecting Quze (PC3) and Daling (PC7), between the tendons of m.palmris longus and m.flexor carpi radialis.

Non-acupoint (NP): 4 cuns above the transverse crease of the wrist, at the middle point of the line connecting Jianshi(PC5) and Ximen (PC4).

2-Determining the Light Wave Irradiating Points and the Signal Detecting Points

In order to decrease the personal influence of the remotion of the detection probe, we chose Neiguan (PC6) acupoint and the reference point which was 1cm off the PC6 in this study as the signal detecting points, and placed the double fiber probe immovably on them. In the study, the non-meridian line is in the ulnar side of the pericardium meridian line, and the distance between the meridian line and the non-meridian line is 1cm. The light wave irradiation points were chosen at PC5, NP, PC4 in the pericardium meridian line, and their corresponding points (1-3) in the non-meridian. In order to improve the experimental precision, we used a precise location device as shown in Figures 3 and 4 in the study.

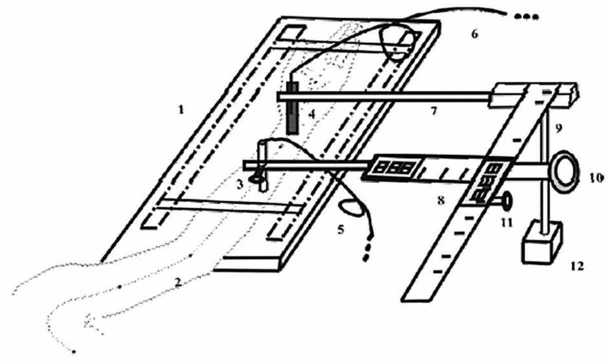

Figure 3. Diagram of the precise device for locating measurement points.

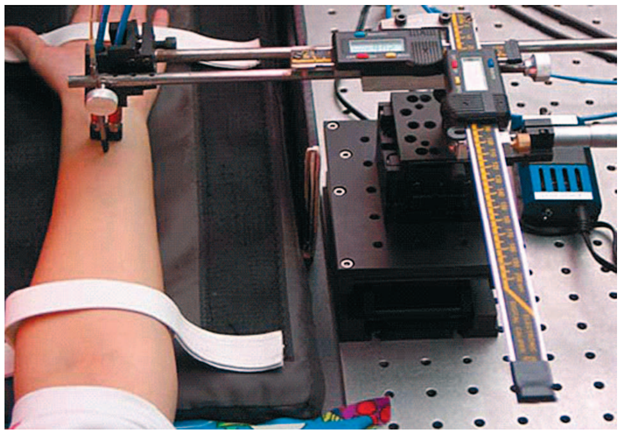

Figure 4. A precise location device for measuring the properties of light propagating along meridian.

The Detecting Method

When testing, subjects sat with a good seat height and an appropriate posture; laid flat arms; tied up the desktop blood pressure cuff onto subjects'right proximal arms, where the lower border of the cuff was 2cm above the elbow, fixed the detection probe immovably on the Neiguan (PC6) acupoint and the reference point which was 1cm off the PC6; and put irradiating fiber onto the selected irradiating points. First, we detected and recorded the optical transport signals along the meridian under resting state; then pressurized them to 100 mmHg, 15seconds later detected and recorded the optical signal data, then reduced the pressure completely to zero, and had a rest for 2 minutes; next, getting in on the action, we detected and recorded the optical signal data, respectively in turn under the pressures of 130 and 160 mmHg. Each time, three numbers were recorded, and the mean of the three recordings was used for data analyses.

Statistical Analysis

The results were analyzed using SPSS11.5 software (SPSS for Window).All data in the study were recorded with $\overline{x} \pm S$. Measurement data were analyzed with One-way ANOVA Model, LSD Post Hoc Tests; overall comparison between groups used General Linear Model, Multivariate. All test results adopted $P < 0.05$ as the standard for significant difference.

Results and Analysis

1.1 Comparison of Relative Attenuation Rate of the 785nm Laser Light Propagating (Same Distance) along pericardium meridian Line and along non-meridian Line under different pressures (see Figure 5).

Figure 5 shows the differences of relative attenuation rate (N=36) of the 785nm laser light propagating (same distance) along pericardium meridian line and along Non-meridian line under four different pressures.

The difference of optical transport characteristics along pericardium meridian line and along non-meridian line was significant: under the same pressures (0, 100, 130, and 160 mmHg), the differences of relative attenuation rate of the light propagating (same distance) along pericardium meridian line and along non-meridian line is significant ($P<0.001$), the light wave attenuates slower when it transports along meridians; however, different pressure (100, 130, and 160 mmHg) have no impact on the relative attenuation rate of light propagating (same distance) along pericardium meridian line or non-meridian line ($P>0.05$).

(Notes: the above relative attenuation rate refers to the light attenuation when the light wave transports from PC5 to NP, from PC5 to PC4 along the pericardium meridian line and from References number 1 to References number 2, from References number 1 to References number 3 along the non-meridian line, that is $(S1\text{-}S2)/(S1\times\Delta x) *100\%°)$

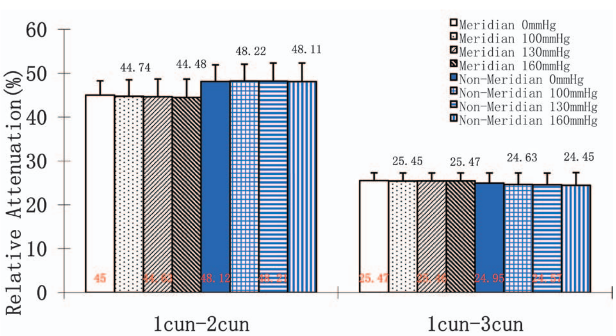

Figure 5. Comparison of relative attenuation rate of the light propagation (same distance) along meridian line and along non-meridian line under different pressures.

1.2 Comparison of optical transport characteristics of the 785nm laser light propagating along pericardium meridian line and non-meridian line (Table 1)

Table 1 showed the data of relative attenuation of the 785nm laser light propagating along pericardium meridian line and non-meridian line under different pressures, and the statistical analysis showed that different pressure had no impact on the relative attenuation of light propagating along pericardium meridian line or non-meridian line ($P>0.05$).

1.3 Comparison of Light Signals at PC5 and at the Referring points at the same level in non-meridian under Different Pressures

Comparison of Light Signals at References number 1 under different pressures and under 0mmHg pressure.

Figures 6 and 7 compare the mean of light signals at PC5, NP in pericardium meridian and at the Referring Points(1, 2) At the same level in non- meridian under different pressures, through statistical analysis, the results show that under four different pressure situations, the optical signal at acupoint (PC5) and non-acupoint(NP) along the meridian are significantly different with the corresponding reference points along the non-meridian line ($P<0.001$); the optical signal on the meridian line is stronger than the non-meridian one; the optical signals are strikingly different at acupoints, non-acupoints and reference points between 0mmHg pressure and 100, 130, and 160mmHg pressures ($P\leq 0.001$); however,

Table 1. Comparison of transport properties of 785nm light wave along pericardium meridian line and along non-meridian line (%)

Subject	(PC5- References number 1)/PC5				(NP~ References number 2)/NP			
	0 mmHg	100 mmHg	130 mmHg	160 mmHg	0 mmHg	100 mmHg	130 mmHg	160 mmHg
No.1	88.64	87.51	93.23	95.57	66.22	32.36	36.69	33.01
No.2	62.17	65.21	64.13	62.49	93.7	90.51	84.67	80.95
No.3	84.38	86.58	87.25	86.76	95.67	96.8	97.25	97.49
No.4	61.34	69.47	71.01	77.22	86.83	89.98	93.88	95.11
No.5	97.58	98.89	98.5	98.56	99	99.28	99.27	98.91
No.6	88.82	89.37	88.81	87.2	94.64	95.17	93.24	92.23
No.7	87.45	89.01	90.18	91.3	96.36	98.37	98.61	98.67
No.8	19.27	22.75	37.99	41.56	16.17	20.65	33.12	28.34
No.9	73.75	77.34	78.92	80.14	76.36	76.21	81.86	82.64
No.10	21.37	35.94	39.54	43.25	74.79	76.05	84.25	84.77
No.11	75.77	75.24	78.74	76.68	69.06	68.05	69.99	72.29
No.12	36.8	26.36	33.11	27.19	28.63	19.38	21.2	21.5
No.13	31.01	27.78	34.9	43.23	90.65	95.96	96.74	97.95
No.14	67.55	67.44	70.64	67.01	85.55	83.77	88.52	86.95
No.15	53.05	58.42	56.24	59.53	84.41	87.25	88.22	87.02
No.16	34.88	29.61	49.72	45.85	60.61	64.51	66.6	67.17
No.17	81.65	88.68	84.63	88.23	70.45	83.84	77.93	87.48
No.18	74.31	69.58	73.79	71.9	94.16	96.52	97.87	98.6
No.19	35.9	41.48	51.4	48.87	66.12	58.09	66.73	73.65
No.20	83.89	83.51	87.16	87.6	93.95	89.11	90.27	90.96
No.21	83.33	82.71	88.77	87.05	96.71	95.69	97.38	95.98
No.22	28.56	13.49	39.17	52.02	96.39	98.93	99.09	99.62
No.23	83.28	85.04	86.83	87.88	98.29	98.65	98.89	99.34
No.24	30.08	26.23	48.68	31.21	66.74	76.9	74.26	74.35
No.25	84.52	86.49	88.77	89.68	95.42	97.34	97.97	97.93
No.26	58.44	61.41	67.27	67.37	76.94	82.56	88.33	93.28
No.27	80.92	85.53	87.53	88.86	61.53	70.11	79.85	84.57
No.28	18.18	25.62	35.51	37.25	69.97	75.76	76.79	77.48
No.29	53.01	53.9	52.05	29.47	65.54	67	71.47	69.12
No.30	80.65	82.2	84.66	84.36	94.92	93.43	94.22	93.6
No.31	82.41	84.71	85.53	85.61	99.19	98.83	99.24	98.99
No.32	91.34	92.43	93.35	93.37	96.43	97.3	97.88	98.8
No.33	30.84	45.26	41.65	50.98	76.95	83.25	88.05	91.02
No.34	79.88	84.13	86.11	88.18	89.44	95.29	97.59	93.9
No.35	89.54	93.72	93.88	95.83	97.26	95.9	96.94	96.63
No.36	75.04	80.21	84.66	85.46	97.69	98.5	99.59	99.73
Mean	64.16±24.72	65.92±25.36	70.40±21.17	71.17±21.55	81.19±19.33	81.87±21.10	84.01±19.39	84.45±19.85

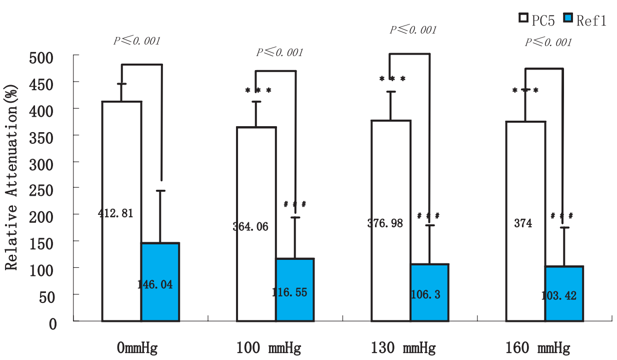

Figure 6. Light signals at PC5 and at the referring point at the same level in non- meridian under different pressure
Notes: Comparison of Light Signals at PC5 under different pressures and under 0mmHg pressure;

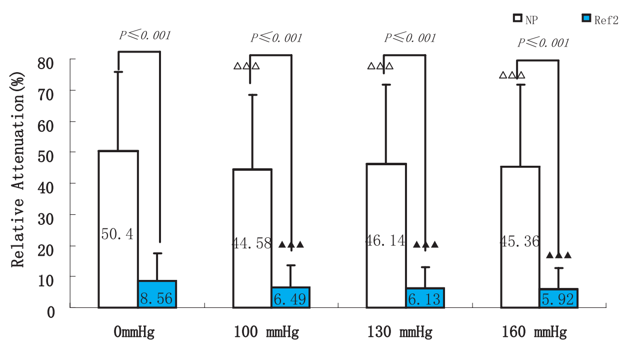

Figure 7. Light signals at non-acupoints and at the referring points(References number 2) at the same Level in non-Meridian under different pressure.
Notes: Comparison of Light Signals at Non-acupoints under different pressures and under 0mmHg Pressure; Comparison of Light Signals at References number 2 under different pressures and under 0mmHg pressure.

no difference was found between 100, 130, and 160mmHg pressures.

Discussion

The phenomenon of PSM refers to the subjects' subjective feelings of sourness, numbness, distention, heaviness and other special sense under stimulated acupuncture points which could be transported along ancient meridians. This phenomenon has been documented in ancient medical books as early as 2,000 years ago, the Yellow Emperor's Internal Classic (Huang Di Nei Jing) said that "If you puncture the qi point, the needle will travel in the lane." and "The meridian qi travels six cuns in one breathing time." Meanwhile, it is the key point in acumoxa clinic to approach effect, so doctors in generations valued the relationship between "obtaining qi" "provoking qi" and the acupuncture effect, and they also emphasized that "provoking qi to the illness area". The Lingshu Small Needle Explaination said "qi reaching to the illness area is effective in acupuncture". Ming dynasty acupuncturist Yang Jizhou in his "Great Compendium of Acupuncture and Moxibustion " stressed that: "While needling acupoint, we must first make the qi directly to the illness area."

The PSM phenomenon mainly refers to the subjective feeling, but it must relate to the sensory nerves and information materials. In recent years, many new achievements in this field at home and abroad provide a good clue for us to study the phenomenon of meridian. However, in the past researches, most of them chose acupuncture needles, moxibustion as the points stimulating methods. Because of characteristics of acumoxa, and the interference caused by participants themselves and acupuncturists' proficiency of acumoxa, experiments always were biased and could not be double blind and randomize, or repeat them. The laser has advantages of direction, high brightness, good color and good coherence. When one uses a laser stimulating the skin or acupoints, the treatment parameters can be adjusted independently and it will be non-invasive with no pain. Furthermore, when the laser irradiates points of skin, 40% of the energy is absorbed by skin, so it combines the dual role of acupuncture and moxibustion. Therefore, we used laser irradiation instead of the traditional acupuncture to stimulate acupuncture points which could reduce the bias from both researchers and participants (15-17), and make the research of meridian phenomenon real objective.

Optical transmission of biological tissues has been the optical research focus in recent years. Since the optical properties parameters of tissues can reflect the physiological and pathological state of tissues, so precisely managing optical properties parameters of tissues is the key point to achieve optical diagnosis, treatment or health care. The non-invasive testing of optical properties of biological tissues is taken through the skin surface. By the tissue optical theory known, when a bunch of light irradiates biological tissue, a portion of the light is transmitted into tissue, then scattered, and absorbed constantly; some light is absorbed by tissues, some is radiated as diffuse light from the surface of the body(18,19), as shown in Figure 8. The distribution characteristics of diffuse light from tissues reflected the optical properties of biological tissue at a certain laser parameters (20). Because the radiation photons from the surface carries inner information of the organism, we can invert or calculate the related optical properties of tissues by measuring the diffuse emittance of the body, uniting the diffusion approximation model and nonlinear optimization (21,22). Therefore, this non-destructive measurement method in the biomedical optics has been widely used (22-24). In our study, combining our knowledge background and the subject characteristics, we applied the medical photonics theory and measurement techniques to the research of the optical properties of human body meridians. In a previous study (10), we compared the light attenuation of 633nm, 658nm,

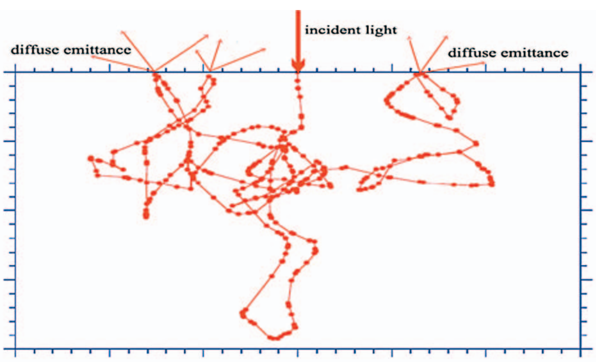

Figure 8. Schematic diagram of diffuse emittance from tissue surface.

785nm wavelength laser light transporting along the pericardium meridian and the non-meridian direction, and we found that 785nm wavelength laser light attenuated slower than 633nm, or 658nm wavelength light, when they transported along meridian. Moreover, the light signal decreases as the frequency increases in the low frequency range (0~50Hz). Therefore, in this experiment, we choose the 785nm wavelength with frequency 10HZ laser light to observe the optical transport characteristics along pericardium meridian under different pressures (0, 100, 130, and 160 mmHg) when the laser irradiates PC5, NP, and PC4 points.

The results of this study showed that under the same pressure and the same level of laser irradiation, the optical signals at acupoints or non-acupoints along pericardium meridian were stronger and attenuated slower than along non-meridian which was similar with the previous study (10) and supported the clinical points-selecting principles of “selecting acupoints along meridians” and “better incorrect acupoint than incorrect meridian”. The difference in optical transport properties between meridian and non-meridian direction was apparent, while the propagation distance is short. In other words, the difference was decreased when the light propagation distance was increased (10). However, this study also found that the attenuation in a longer distance (1cun-3cun) is different from the previous study done with the shorter distances (2.5cm-4cm or about 1cun-1.5cun). This will be clarified, if we can magnify the signal or conceal the background noise. To further quantitatively analyze the light attenuation characteristics under the state of meridian block, we respectively compared the light signals of laser irritation points on meridian and non-meridian, and the relative attenuation rate of the light propagating the same distance along meridian and non-meridian under four different pressures. The results showed that the light signals of irradiation points were significantly different between under a certain pressure (100 mmHg) block state and under no pressure (0 mmHg), in which the light signal was weaker in the state of pressure. However, the light signals just changes little as the pressure continues to increase (130, and 160 mmHg). It indicates that laser acupuncture can cause light signals transport along the meridian direction. It can be blocked by pressure as the phenomenon of PSM induced by traditional acumoxa. It has once again proved from the optical view that the phenomenon of PSM is an objective reality and can be blocked. The results also confirmed that the use of optical methods will be epoch-making significance in the modern study of the meridian.

Therefore, based on these results, we believe that: human meridian lines may be good meridians of light, that is to say, the light has the trend to transport along meridians and the transmission can be blocked by pressures at the same time. What is the material basis of light transmission? Although some scholars believe that there are more abundant liquid collagen fibers around meridians which can highly transmit the infrared light, it is far to explain the optical meridian phenomenon comprehensively and reasonably. When the light wave transports along the meridian line direction, the interactions with tissues and their possible mechanism, and the quantitative analysis and the calculations of tissue optical properties need to be further studied.Therefore, it is a pressing problem to carry out the research on physical properties of meridians and acupoints by using the cross-disciplinary advantages and modern scientific instruments and technology.

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