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SOME FUNDATION OF PULSE FEELING IN CHINESE MEDICINE

Wang, W.K.[1,2], Wang Lin, Y.Y.[3], Hsu, T.L.[1], and Ching, Y.[1]

[1]Biophysics Laboratory, Institute of Physics, Academia Sinica, Taipei, Taiwan, 11529 R.O.C.

[2]Joint appoint with Institute of Biomedical Engineering, Yang-Ming Medical Collage

[3]Department of Physics, National Taiwan Normal University, Taipei, Taiwan, 11718 R.O.C.

THE HISTORY OF PULSE FEELING

As we mentioned in several of our reports (1,2,3), the fundamental concept of pulse feeling is "the resonance of organs with the heart". This concept was cited in Chu-Li (周禮) about three thousand years ago.

The traditional way of pulse feeling did not feel just one spot, the wrist radial artery. There were at least nine spots, three at the head, three at the hand and three at the foot. It was described as three different areas with nine spots (三部九候). The nine spots were correlated to the nine internal organs. This kind of pulse feeling had been going on for about one thousand years. Until about the end of Han dynasty (漢朝), "Nan-Ching" (難經) suggested that Tai Yuan (太淵) had all the components of the pulse.

（一難曰：十二經中皆有動脈，獨取寸口以決五臟六腑死生吉凶之法何謂也，然寸口者脈之大會手太陰之動脈也。）

內經三部九候論：「帝曰：何謂三部？歧伯曰：有下部，有中部，有上部，部各有三候，三候者，有天，有地，有人也，必指而導之，乃以爲眞，上部天，兩額之動脈，上部地，兩頰之動脈，上部人，耳前之動脈，中部天，手太陰也，中部地，手陽明也，中部人，手少陰也，下部天，足厥陰也，下部地，足少陰也，下部人，足太陰也。」

內經三部九候論曰：「獨小者病，獨大者病，獨疾者病，獨遲者病，獨熱者病，獨寒者病，獨陷下者病。」

Since then, physicians have slowly shifted to this simplified diagnosis. Especially during Sung dynasty (宋朝) the social restriction forbade physician who was usually man to touch the body of a lady, this simplified method which felt only the radial artery became popular and later on, turned to be the standard method.

THEORY OF HOMOGENOUS CIRCUIT RELATED TO THE MERIDIAN

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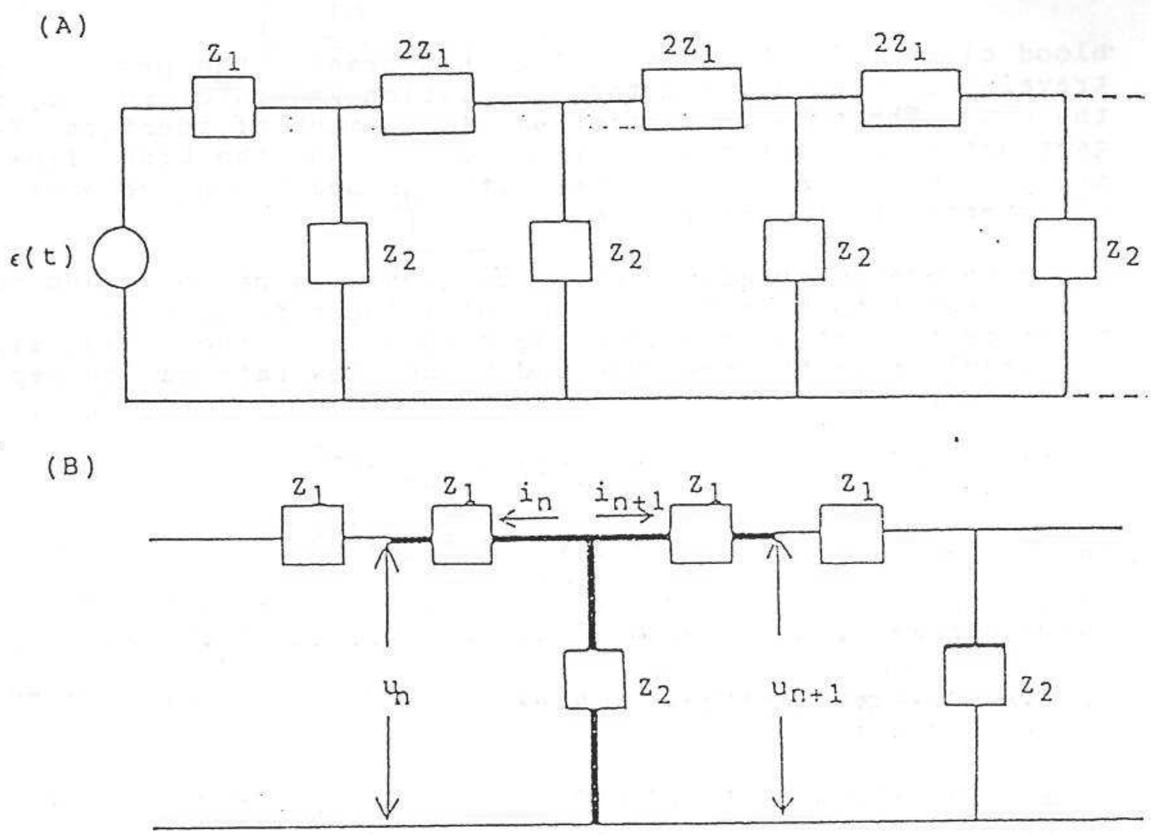


FIGURE 1. The analogy network of the blood circulation system.
(A) A homogenous network under a pressure generator $\varepsilon(t)$.
(B) Pressures and blood flows associated with nth section of network.

What did they feel at these spots? The theory of pulse feeling in ancient time that felt nine spots instead of one was related to the meridians in the body.

In the theory of Chinese medicine, the meridians, which are the hypothetic lines that connect the acupuncture points, are the pathways of Chi (氣). In our previous paper we have deduced that meridian may exist as a series of resonant arterial trees that vibrate as lumped elements from the energy consumption point of view. Here some theoretical work based on homogenous circuit will be discussed. This is a simplified meridian model. However, it does give some feeling about the property of meridian.

As the pressure wave transmits through the blood vessel, the inertance L, resistance R and compliance C of the artery or arterial tree are used to describe the characteristic property of the composed segments. This electrical analog approach has long been used in fluid dynamics (4), since Landes (5) pointed out the analogy between the pressure pulse transmission in an elastic tube and a voltage pulse along a telephone cable.

We assume that the blood vessels are represented by a network of series connected homogenous elements for one particular blood circulation branch. Along this branch, the pressure pulse travels all the way from the oscillation generator (heart) toward the end. The network consisting of a number of identical T-sections is illustrated in Figure 1(A). And the blood flow rate i and pressure drop u associated with nth section of network are illustrated on Figure 1(B)(6).

The pressure pulse generated by the heart is periodic and may be decomposed into harmonic sources of integer frequencies of the heart beat. Let us consider one component of the pulse, say $\varepsilon(t) = \varepsilon_0(w)e^{jwt}$, then the pressure and blood flow rate may be represented in the form:

$$u_n(t) = U_n e^{j\omega t} \qquad u_{n+1}(t) = U_{n+1}e^{j\omega t}$$

$$i_n(t) = I_n e^{j\omega t} \qquad i_{n+1}(t) = I_{n+1}e^{j\omega t} \qquad \text{(Eq.1)}$$

This requires the linear relation between u and i and this requirement is usually met when the body is quiet at rest (7,8).

By Kirchhoff's equation, we have

$$U_n = (Z_1 + Z_2)I_n - Z_2 I_{n+1}$$

$$-U_{n+1} = -Z_2 I_n + (Z_1 + Z_2)I_{n+1} \qquad \text{(Eq.2)}$$

Where Z_1 and Z_2 are the complex impedances of the elements connected in series and in parallel respectively.

The general solutions of the equations are

$$I_n = A\exp(-\gamma n) + B\exp(\gamma n) \qquad \text{(Eq.3a)}$$

$$U_n = C\exp(-\gamma n) + D\exp(\gamma n), \qquad \text{(Eq.3b)}$$

with the restriction

$$\cosh\gamma = 1 + \frac{Z_2}{Z_1}. \qquad \text{(Eq.4)}$$

If we consider the branch consisting of a large number of identical sections, we may neglect the reflected wave, then Eq.3a and Eq.3b becomes

$$I_n = A\exp(-\gamma n)$$

$$U_n = C\exp(-\gamma n)\cdot$$

and

$$\frac{U_{n+1}}{U_n} = \exp(-\gamma)$$

$$\frac{I_{n+1}}{I_n} = \exp(-\gamma)$$

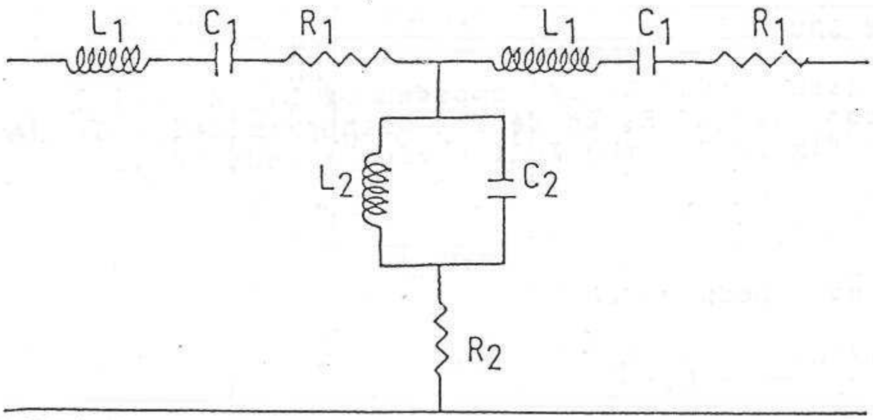


FIGURE 2. Proposed T-section of a particular circulation branch.

γ is called the propagation constant. In general, it is a complex quantity given by

$$\gamma = \alpha + j\beta \quad \text{(Eq.5)}$$

where α and β are, respectively, the attenuation constant and phase constant per section.

The blood flow I_s through the nth shunt to the vein is given by

$$I_s = I_n - I_{n+1} = I_n(1 - \exp(-\gamma))$$

and the magnitude of I_s is

$$|I_s| = |I_n|[1 + \exp(-2\alpha) - 2\exp(-\alpha)\cos\beta\,]^{\frac{1}{2}}. \quad \text{(Eq.6)}$$

In general Z_1 and Z_2 will be varied with frequency ω, and if, over any frequency range, α is zero, such waves will pass the network without attenuation. The condition for α to be zero is that

$$\cosh\gamma = \cosh(j\beta) = \cos\beta = 1 + \frac{Z_1}{Z_2} \quad \text{(Eq.7)}$$

The possible limits of $\cos\beta$ are +1 and -1. The condition for a wave pulse to lie within a pass band is that, at the frquency of the input pressure, the impedances Z_1 and Z_2 must satisfy the condition

$$|1 + Z_1/Z_2| \leq 1 \quad \text{(Eq.8)}$$

In the presence of resistance, the condition $|1 + Z_1/Z_2| \leq 1$ could hardly be fulfilled. However if

$$Z_1/Z_2 = 0 \quad \text{(Eq.9)}$$

then $\alpha = 0$, $\beta = 0$ and from Eq.6, we have $|I_s| = 0$. The pulse of the particular frequencies which satisfy the condition in Eq.9 will propagate toward the next element without attenuation and phase change and even without any flow leakage through the shunt.

We further assume that Z_1 is composed of L_1, R_1 and C_1 in series, and Z_2 is composed of R_2 in series with paralleled C_2, L_2. This is shown in Figure 2., the full series impedance is

$$Z_1 = j(\omega L_1 - \frac{1}{\omega C_1}) + R_1$$

and the shunt impedance is

$$Z_2 = \frac{-j(\omega L_2/\omega C_2)}{\omega L_2 - \frac{1}{\omega C_2}} + R_2$$

In this case, the restriction $Z1/Z2 = 0$ could be met in two conditions:

Firstly, if R1 is negligibly small and

$$\omega_1 = \frac{1}{\sqrt{L_1 C_1}} \qquad \text{(Eq.10)}$$

Secondly, R_1 and R_2 need not be negligibly small, but

$$\omega_2 = \frac{1}{\sqrt{L_2 C_2}} \qquad \text{(Eq.11)}$$

In order to prove this theoretical interpretation, we performed the following experiments.

Frequency Selection at Different Meridian

The pulses of nine acupuncture points, each corresponds to a specific meridian, were checked. Three points on hand were Tai Yuan (太淵, on wrist radial A.), Shen Men (神門, on wrist ulnar A.), and Hoh Ku (合谷, on back hand radial A.). Three points on foot were Tai Chung (太沖, on foot 1st dorsal metatars A.), Chung Yang (衝陽, on foot dorsal pedis A.), and Tai Tsih (太谿, on ankle post tibial A.). And the rest three points on head were Han Yen (頷厭, on head parietal Br.), Erh Men (耳門, on ear Superf. temporal A.) and Chuan Lien (顴髎, on face tranverse facial A.). The tested persons were aged between <u>twenty three to forty three years.</u> During the experiment they were asked to <u>lie down quietly</u>. The shape of the pulse was then recorded with a <u>pressure transducer</u> (PSL-200GL, Kyowa Electronic Instruments Co. Ltd. Japan) which was fixed on the skin of the acupuncture points by scotch tape and an adjustable belt with a small button to give the suitable pressure on the transducer. Our criterion of a good measurement is to seek the <u>largest amplitude</u> of the pressure wave. The transducer was connected to an oscilloscope and through an A/D converter to an IBM PC. Pulse shape was analyzed with Fourier transform software using T(period) = 1 pulse as described previously(3).

As shown in Figure 3 the pulse shapes and their Fourier transformed spectrums were dramatically different from each other.

Using Tai Yuan (太淵) as control, the variations of the harmonics between Tai Yuan and seven other acupuncture points of five persons

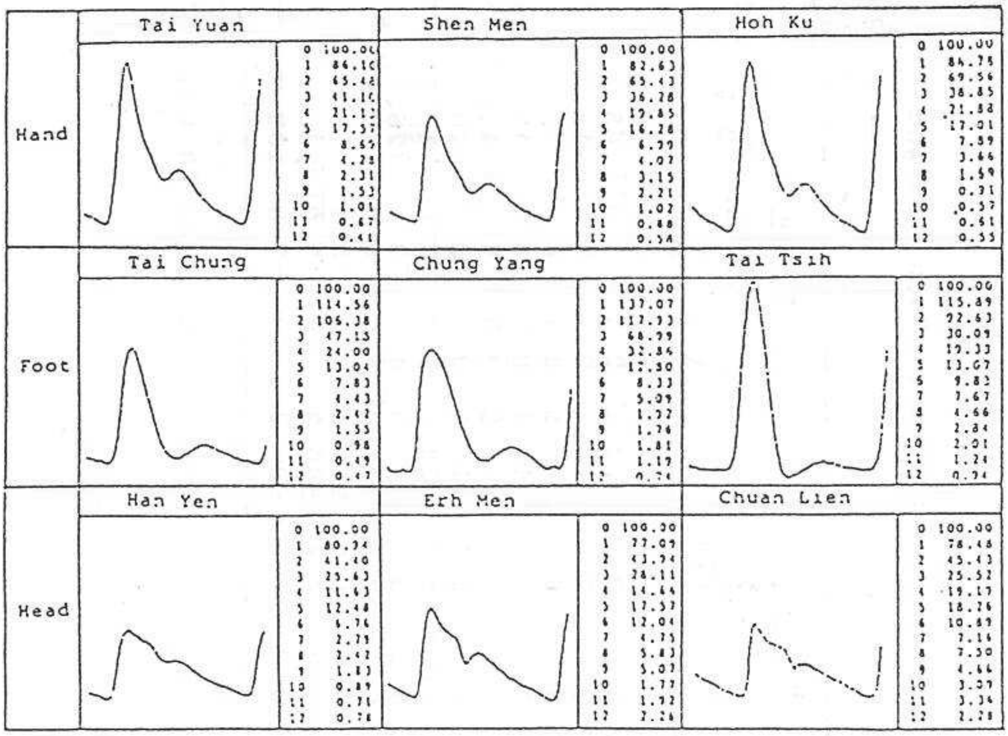


FIGURE 3. The pulse shapes of nine acupuncture points and their normalized Fourier transformed spectrums. The amplitude of the zero frequency term was used as 100% standard. The data are presented as percentage of amplitude of each frequency compared to the amplitude of zero frequency.

are given in Tables 1-7 and Figures 4-6. Since the pulse of Chuan Lien was quite difficult to get, it is not included in these figures and tables.

Figure 7 shows the averaged variations of the harmonics of five persons. While the difference between subjects was large, nevertheless the frequency selectivity on the body is obvious. On the head some higher frequencies were preferred. However some lower frequencies were preferred on foot. Similar result has been suggested by O'Rourk and Taylor (9). If we look at these data more carefully (Figures 4-6), each individual seems to have more than one selected frequencies. At head, the harmonic number 6 could be related to ω_1 in Eq.10. At foot, the harmonic number 2 could be related to ω_1 in Eq.10 which is artery specific, because there is same selective peak for all points at the same area. While the another selected frequency may be related to ω_2 in Eq.11, which could be meridian specific. Although every person tested has another selective peak or band, the meridian specific frequency is not very clear in these data. There could be two reasons for this: (1) All testing subjects were asked to lie down during the pulse measurement. Lying down may not be a good posture to measure the resonance of meridian. (2) Only Kung-Fu master will have sharp meridian specific frequency as shown in Figure 8.

We have therefore partially shown that there is some kind of frequency selection for blood to distribute at different meridians which lead to different part of the body.

TABLE 1. Difference of the normalized amplitude of different harmonics between Shen Men and Tai Yuan.

T/n	Person 1 S.D.% (C)	Person 1 S.D.% (T)	Person 1 D.%	Person 2 S.D.% (C)	Person 2 S.D.% (T)	Person 2 D.%	Person 3 S.D.% (C)	Person 3 S.D.% (T)	Person 3 D.%	Person 4 S.D.% (C)	Person 4 S.D.% (T)	Person 4 D.%	Person 5 S.D.% (C)	Person 5 S.D.% (T)	Person 5 D.%
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	2.7	2.9	-4.0	1.2	3.2	-8.4	1.9	3.0	-0.6	2.7	2.3	-2.2	2.6	1.8	-3.7
2	3.0	1.5	-0.1	1.8	2.8	5.3	2.4	1.9	-2.3	3.7	7.1	-9.2	2.8	1.5	-12.2
3	2.5	4.0	-11.7	7.5	7.2	-4.5	8.3	5.8	-8.7	3.5	8.7	2.5	5.4	6.6	3.1
4	2.2	2.1	-6.1	2.9	4.7	-5.8	7.0	3.1	-10.0	2.3	3.6	-10.2	0.6	4.2	-13.2
5	2.6	2.9	-7.4	4.9	6.3	-5.3	1.1	1.8	-4.7	2.5	5.6	-5.5	3.6	4.4	11.7
6	7.0	5.5	-19.5	13.8	9.3	-10.6	6.0	5.1	-7.0	4.2	11.2	10.5	3.8	8.5	10.1
7	6.8	3.7	-5.0	8.0	5.9	7.1	10.7	3.6	-3.7	3.5	4.1	28.1	2.9	2.8	11.3
8	10.2	4.5	36.3	7.9	3.7	14.1	6.2	7.2	48.0	4.1	3.7	49.3	4.1	3.4	26.7
9	11.4	7.6	44.3	12.5	7.5	30.4	6.0	4.3	65.1	6.3	7.9	141.9	5.6	4.8	50.8
10	7.4	7.8	0.8	19.2	9.2	69.0	11.6	5.4	87.9	14.6	8.5	218.5	7.6	8.1	76.9
11	5.9	11.9	31.0	9.0	5.6	72.3	16.9	7.8	242.1	14.9	8.6	569.3	8.5	3.0	66.4
12	5.4	16.4	42.5	9.7	7.2	67.9	22.2	8.9	153.0	9.7	7.0	999.3	13.0	7.0	102.9

Number or data = 6

S.D.%: standard deviation

C: Tai Yuan

T: Shen Men

D%: the percent difference between C and T

TABLE 2. Difference of the normalized amplitude of different harmonics between Hoh Ku and Tai Yuan

T/n	Person 1			Person 2			Person 3			Person 4			Person 5		
	S.D.%		D.%	S.D.%		D.%	S.D.%		D.%	S.D.%		D.%	S.D.%		D.%
	(C)	(T)		(C)	(T)		(C)	(T)		(C)	(T)		(C)	(T)	
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	2.7	2.0	0.8	1.2	2.1	-4.8	1.9	1.3	-4.8	2.7	1.8	5.0	2.6	0.7	-3.7
2	3.0	5.0	6.2	1.8	3.3	11.0	2.4	3.9	-2.9	3.7	1.4	-2.4	2.8	2.7	-9.7
3	2.5	3.4	-5.5	7.5	3.5	-4.7	8.3	9.5	-3.8	3.5	9.8	12.4	5.4	12.2	2.7
4	2.2	7.4	3.5	2.9	1.6	2.5	7.0	6.8	-1.6	2.3	5.1	3.6	0.6	3.2	-13.4
5	2.6	4.5	-3.2	4.9	2.2	-3.5	1.1	4.4	2.2	2.5	2.1	3.9	3.6	11.8	6.3
6	7.0	8.5	-9.2	13.8	1.3	-14.5	6.0	8.4	-7.3	4.2	19.3	34.2	3.8	18.1	-2.3
7	6.8	18.1	-14.6	8.0	1.5	3.0	10.7	6.9	-9.0	3.5	15.5	13.8	2.9	2.9	18.2
8	10.2	29.6	-26.9	7.9	1.4	3.5	6.2	5.3	45.2	4.1	6.1	12.0	4.1	10.0	43.8
9	11.4	53.5	-40.9	12.5	4.5	-2.0	6.0	3.8	52.6	6.3	9.7	34.3	5.6	13.5	70.4
10	7.4	40.4	-43.9	19.2	3.7	10.5	11.6	11.6	50.7	14.6	28.0	80.2	7.6	14.0	94.1
11	5.9	15.8	-8.8	9.0	6.0	18.9	16.9	6.9	161.3	14.9	18.4	33.2	8.5	14.1	76.5
12	5.4	24.0	36.4	9.7	7.5	10.2	22.2	7.3	111.2	9.7	9.1	27.3	13.0	24.1	87.6

Number of data = 6

S.D.%: percent standard deviation

C: Tai Yuan

T: Hoh Ku

D%: the percent difference between C and T

TABLE 3. Difference of the normalized amplitude of different harmonics between Tai Chung and Tai Yuan.

T/n	Person 1 S.D.% (C)	Person 1 S.D.% (T)	Person 1 D.%	Person 2 S.D.% (C)	Person 2 S.D.% (T)	Person 2 D.%	Person 3 S.D.% (C)	Person 3 S.D.% (T)	Person 3 D.%	Person 4 S.D.% (C)	Person 4 S.D.% (T)	Person 4 D.%	Person 5 S.D.% (C)	Person 5 S.D.% (T)	Person 5 D.%
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	2.7	0.3	33.1	1.2	2.1	18.6	1.9	1.4	1.2	2.7	3.7	2.8	2.6	3.0	12.5
2	3.0	1.2	62.5	1.8	1.7	53.2	2.4	4.2	60.2	3.7	2.2	28.8	2.8	3.3	97.5
3	2.5	3.7	14.7	7.5	4.4	-29.0	8.3	5.3	3.6	3.5	14.6	-1.6	5.4	8.0	16.1
4	2.2	3.9	13.6	2.9	6.2	-23.0	7.0	1.7	3.3	2.3	5.3	-18.1	0.6	3.4	-41.3
5	2.6	5.1	-25.8	4.9	7.4	-44.9	1.1	2.2	-21.6	2.5	9.6	-25.7	3.6	1.7	-27.3
6	7.0	6.4	-9.9	13.8	9.4	-35.5	6.0	3.7	-28.7	4.2	9.3	-3.4	3.8	5.3	-36.5
7	6.8	9.4	3.4	8.0	10.0	-15.1	10.7	2.8	12.6	3.5	8.7	9.6	2.9	5.9	-15.3
8	10.2	12.1	4.5	7.9	12.4	-19.4	6.2	3.5	68.3	4.1	9.8	8.4	4.1	7.4	29.4
9	11.4	17.1	1.4	12.5	14.9	-6.9	6.0	6.7	40.8	6.3	10.1	10.7	5.6	4.8	13.8
10	7.4	10.5	-3.3	19.2	15.4	23.4	11.6	8.1	72.1	14.6	16.1	74.4	7.6	7.5	8.1
11	5.9	14.9	-26.5	9.0	16.6	25.4	16.9	10.3	324.3	14.9	24.5	48.0	8.5	11.3	38.6
12	5.4	22.3	15.4	9.7	18.9	16.4	22.2	11.8	167.4	9.7	21.2	21.3	13.0	7.8	100.4

Number of data = 6

S.D.%: percent standard deviation

C: Tai Yuan

T: Tai Chung

D%: the percent difference between C and T

TABLE 4. Difference of the normalized amplitude of different harmonics between Chung Yang and Tai Yuan

T/n	Person 1			Person 2			Person 3			Person 4			Person 5		
	S.D.%		D.%	S.D.%		D.%	S.D.%		D.%	S.D.%		D.%	S.D.%		D.%
	(C)	(T)		(C)	(T)		(C)	(T)		(C)	(T)		(C)	(T)	
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	2.7	1.0	59.2	1.2	3.0	27.9	1.9	3.3	12.6	2.7	2.9	27.0	2.6	3.8	10.9
2	3.0	1.8	80.1	1.8	3.3	65.5	2.4	5.1	86.0	3.7	2.7	122.4	2.8	2.0	42.4
3	2.5	7.0	67.8	7.5	4.2	6.7	8.3	7.9	54.1	3.5	3.3	48.5	5.4	1.6	-0.6
4	2.2	13.7	55.5	2.9	4.4	-15.1	7.0	10.2	54.5	2.3	1.6	5.2	0.6	4.1	-18.3
5	2.6	18.3	-27.2	4.9	8.7	-20.1	1.1	10.8	21.0	2.5	0.7	-6.2	3.6	4.7	-30.8
6	7.0	4.9	-4.1	13.8	9.1	-16.3	6.0	8.9	-2.5	4.2	1.6	-25.4	3.8	4.8	10.2
7	6.8	21.1	18.8	8.0	11.0	3.9	10.7	7.5	71.7	3.5	1.3	-16.4	2.9	5.0	14.8
8	10.2	45.5	-17.1	7.9	13.7	-13.3	6.2	14.7	135.9	4.1	3.3	8.2	4.1	8.5	20.9
9	11.4	17.3	14.6	12.5	14.3	-8.6	6.0	16.7	89.9	6.3	2.6	-24.6	5.6	6.5	42.8
10	7.4	16.2	79.1	19.2	12.7	18.7	11.6	33.6	72.6	14.6	4.5	-38.5	7.6	10.9	61.0
11	5.9	39.2	76.9	9.0	12.2	17.3	16.9	33.4	243.2	14.9	4.9	-23.3	8.5	12.1	23.0
12	5.4	35.1	82.0	9.7	21.6	3.8	22.2	39.1	69.0	9.7	6.4	7.4	13.0	12.0	12.5

Number of data = 6

S.D.%: percent standard deviation

C: Tai Yuan

T: Chung Yang

D%: the percent difference between C and T

TABLE 5. Difference of the normalized amplitude of different harmonics between Tai Tsih and Tai Yuan

T/n	Person 1			Person 2			Person 3			Person 4			Person 5		
	S.D.%		D.%	S.D.%		D.%	S.D.%		D.%	S.D.%		D.%	S.D.%		D.%
	(C)	(T)		(C)	(T)		(C)	(T)		(C)	(T)		(C)	(T)	
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	2.7	1.7	34.6	1.2	5.8	23.5	1.9	2.3	26.2	2.7	3.4	18.9	2.6	6.2	-14.9
2	3.0	2.4	41.5	1.8	2.3	59.1	2.4	3.4	93.8	3.7	4.3	37.2	2.8	4.9	22.5
3	2.5	3.8	-26.8	7.5	3.7	-7.5	8.3	7.6	48.3	3.5	5.6	-5.1	5.4	16.2	-43.5
4	2.2	7.5	-8.5	2.9	5.6	-4.1	7.0	9.7	33.6	2.3	8.5	-16.7	0.6	7.4	-26.9
5	2.6	10.0	-25.6	4.9	5.0	-39.3	1.1	8.0	-29.4	2.5	6.1	-27.9	3.6	10.4	-33.9
6	7.0	5.2	13.1	13.8	4.4	-20.8	6.0	11.1	-43.8	4.2	7.9	14.7	3.8	6.6	-0.3
7	6.8	6.5	79.1	8.0	8.6	6.4	10.7	12.2	2.0	3.5	8.1	59.7	2.9	12.7	-14.4
8	10.2	13.4	101.6	7.9	9.5	-10.9	6.2	16.5	28.8	4.1	11.5	64.7	4.1	61.3	-41.9
9	11.4	12.5	85.3	12.5	8.4	-3.6	6.0	13.6	-18.2	6.3	9.0	91.2	5.6	64.5	-29.7
10	7.4	12.3	85.3	19.2	8.3	30.0	11.6	21.0	-18.4	14.6	16.1	241.7	7.6	23.9	78.6
11	5.9	13.8	84.6	9.0	20.5	14.7	16.9	45.6	17.2	14.9	16.3	222.8	8.5	42.0	142.9
12	5.4	8.1	131.3	9.7	20.3	-0.3	22.2	47.8	-52.9	9.7	18.4	196.2	13.0	49.6	276.2

Number of data = 6

S.D.%: percent standard deviation

C: Tai Yuan

T: Tai Tsih

D%: the percent difference between C and T

TABLE 6. Difference of the normalized amplitude of different harmonics between Han Yen and Tai Yuan.

T/n	Person 1			Person 2			Person 3			Person 4			Person 5		
	S.D.%			S.D.%			S.D.%			S.D.%			S.D.%		
	(C)	(T)	D.%	(C)	(T)	D.%	(C)	(T)	D.%	(C)	(T)	D.%	(C)	(T)	D.%
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	2.7	3.0	-6.0	1.2	4.1	-9.4	1.9	4.5	-3.3	2.7	3.0	-1.8	2.6	7.3	-9.9
2	3.0	2.7	-36.8	1.8	2.5	-32.9	2.4	2.9	-30.2	3.7	1.9	-36.8	2.8	12.7	-45.1
3	2.5	8.2	-37.6	7.5	5.6	-43.3	8.3	4.2	-30.5	3.5	4.1	-35.3	5.4	10.7	-16.0
4	2.2	3.2	-45.0	2.9	4.4	-29.4	7.0	7.3	-7.6	2.3	3.9	-41.0	0.6	16.1	-59.4
5	2.6	4.0	-29.0	4.9	2.9	-19.9	1.1	2.8	12.5	2.5	2.5	-9.6	3.6	5.2	-29.7
6	7.0	12.4	-22.2	13.8	11.8	-9.4	6.0	5.7	115.4	4.2	5.9	50.1	3.8	18.1	-11.8
7	6.8	7.9	-35.0	8.0	4.6	-12.1	10.7	9.2	87.6	3.5	10.0	15.2	2.9	13.2	-28.1
8	10.2	4.1	4.5	7.9	2.7	36.4	6.2	9.6	107.9	4.1	3.9	101.5	4.1	28.6	-25.0
9	11.4	9.0	19.3	12.5	16.8	51.0	6.0	7.3	200.4	6.3	5.5	227.4	5.6	37.2	-30.9
10	7.4	33.6	-11.7	19.2	10.9	42.2	11.6	14.0	223.3	14.6	17.3	247.8	7.6	49.9	-20.6
11	5.9	20.4	-5.4	9.0	5.6	132.8	16.9	14.4	87.4	14.9	10.8	292.6	8.5	29.7	-15.4
12	5.4	12.0	92.5	9.7	26.0	138.5	22.2	10.6	157.8	9.7	4.4	547.3	13.0	50.4	28.8

Number of data = 6

S.D.%: percent standard deviation

C: Tai Yuan

T: Han Yen

D%: the percent difference between C and T

TABLE 7. Difference of the normalized amplitude of different harmonics between Erh Men and Tai Yuan.

T/n	Person 1 S.D.% (C)	Person 1 S.D.% (T)	Person 1 D.%	Person 2 S.D.% (C)	Person 2 S.D.% (T)	Person 2 D.%	Person 3 S.D.% (C)	Person 3 S.D.% (T)	Person 3 D.%	Person 4 S.D.% (C)	Person 4 S.D.% (T)	Person 4 D.%	Person 5 S.D.% (C)	Person 5 S.D.% (T)	Person 5 D.%
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	2.7	3.3	-10.5	1.2	3.4	-7.1	1.9	3.2	-3.6	2.7	3.0	0.5	2.6	2.9	-2.2
2	3.0	2.1	-32.9	1.8	2.5	-29.7	2.4	3.4	-20.6	3.7	2.3	-36.7	2.8	2.7	-33.6
3	2.5	7.0	-31.6	7.5	2.9	-35.9	8.3	7.8	-17.8	3.5	2.4	-32.6	5.4	8.3	-9.5
4	2.2	3.8	-30.6	2.9	3.3	-30.2	7.0	7.9	-34.4	2.3	3.9	-32.3	0.6	2.9	-19.8
5	2.6	3.1	0.0	4.9	1.7	-18.0	1.1	6.3	-14.5	2.5	4.0	1.1	3.6	2.3	22.1
6	7.0	10.8	38.6	13.8	3.9	10.8	6.0	5.8	17.9	4.2	5.0	90.9	3.8	6.6	102.7
7	6.8	5.7	11.0	8.0	8.1	0.3	10.7	11.5	9.8	3.5	9.8	60.2	2.9	11.8	21.7
8	10.2	6.4	152.0	7.9	8.0	32.1	6.2	6.6	-5.1	4.1	9.3	174.0	4.1	7.7	56.5
9	11.4	7.7	231.0	12.5	3.1	105.5	6.0	4.6	33.6	6.3	2.9	431.8	5.6	2.0	230.7
10	7.4	28.1	75.5	19.2	17.4	104.0	11.6	13.2	64.9	14.6	16.5	569.1	7.6	21.7	197.5
11	5.9	17.7	187.1	9.0	15.1	123.9	16.9	14.3	16.9	14.9	21.6	441.2	8.5	22.8	108.2
12	5.4	9.2	454.8	9.7	5.9	264.4	22.2	8.6	75.5	9.7	4.6	999.9	13.0	14.9	239.0

Number of data = 6

S.D.%: percent standard deviation

C: Tai Yuan

T: Erh Men

D%: the percent difference between C and T

TABLE 8. The effect of releasing "Chi". The difference of the normalized amplitude and phase angle of different harmonics between Hoh Ku and Tai Yuan before and during releasing "Chi"

	Tai Yuan		Hoh Ku - Before				- During (1)				- During (2)			
T/n	Amp	Phase	Amp		Phase		Amp		Phase		Amp		Phase	
	SD%	SD	D%	SD%	D	SD	D%	SD%	D	SD	D%	SD%	D	SD
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	1.9	2.4	-5.2	2.4	0.6	2.8	1.6	3.5	3.8	2.6	-0.3	3.3	3.2	1.9
2	2.2	5.9	-1.2	2.9	-10.4	6.0	-3.0	6.3	-8.8	3.5	-1.6	4.9	-11.2	2.4
3	4.7	7.0	9.8	4.1	-6.4	9.4	20.2	3.7	-0.6	5.1	25.4	5.7	-1.5	3.9
4	1.0	11.1	4.5	3.4	-17.0	11.7	3.0	2.6	-9.6	9.4	12.4	4.7	-10.6	6.0
5	10.8	11.8	30.4	7.2	-17.8	14.7	51.4	8.9	-7.6	9.0	62.8	7.4	-7.3	7.8
6	8.2	14.6	46.6	6.8	-13.7	19.1	63.8	5.7	9.5	9.7	81.0	6.5	11.0	9.1
7	6.5	17.4	68.5	6.7	-15.1	21.5	69.9	5.5	4.2	12.8	88.1	6.1	6.6	13.9
8	15.5	19.7	133.2	10.8	-4.1	22.9	177.4	8.6	15.7	13.5	182.5	6.7	19.9	12.5
9	10.5	23.5	152.3	13.7	-17.2	117.4	210.1	8.8	-88.5	180.6	241.4	14.8	-155.4	173.8
10	6.6	22.8	54.8	10.0	-19.5	115.3	66.9	4.9	-86.2	176.6	75.3	5.7	-241.2	111.2
11	13.7	27.4	79.5	19.7	-61.9	153.9	116.3	4.8	-229.7	123.0	129.3	7.9	-231.6	109.1
12	10.5	30.4	15.5	21.7	-187.4	143.5	45.0	19.2	-229.1	22.8	44.1	23.4	-235.1	23.5

Number of data = 6

SD: standard deviation

SD%: percent standard deviation

D%: percent amplitude difference between Hoh Ku and Tai Yuan

D: the phase difference between Hoh Ku and Tai Yuan

Before: Before releasing "Chi"

During (1): start releasing "Chi" about 3 minutes

During (2): start releasing "Chi" about 7 minutes

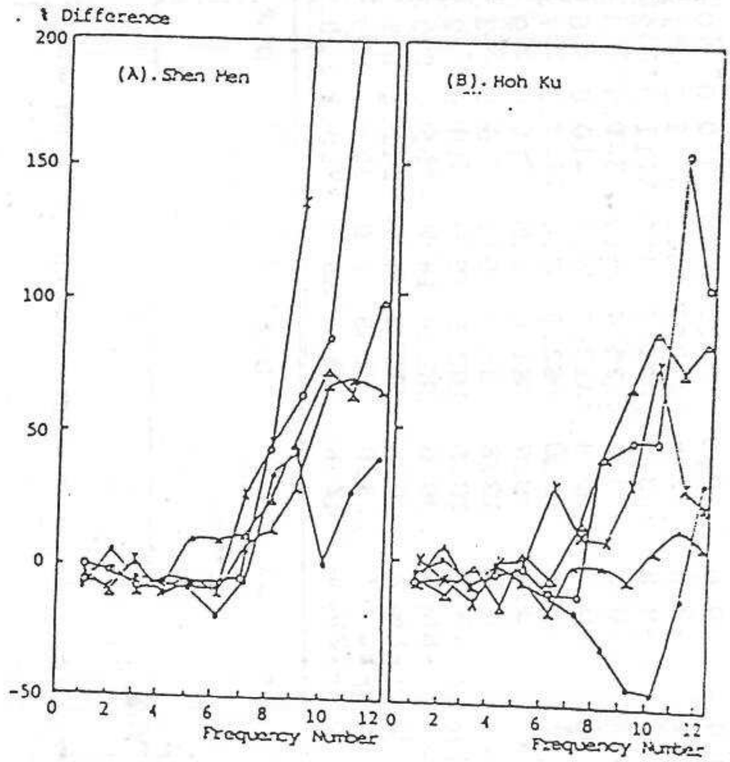


FIGURE 4. The percent difference of the normalized Fourier transformed amplitude of twelve frequencies are shown as 100% $*(C_n' - C_n)/C_n$. ●, x, ⅄, o, Δ represents five different persons. Tai Yuan (C_n) is used as control to compare to:

(A). Shen Men (C_n')

(B). Hoh Ku (C_n')

We may thus suggest that when we examine blood flow in real space, we will find the artery. However, if we examine blood flow in K space (or frequency space) we will find meridians.

Ancient Chinese somehow visualized this and gave thorough exploration about this K space. They developed Chinese medicine and Kung-Fu (功夫) or Chi-Kung (氣功)

The Evidence of CHI (氣) Flow

From our theoretical and experimental results, it seems that the idea of "Chi" is related to the resonance condition of the lumped elements in each meridian.

Should this be true, the person who practices Kung-Fu and knows how to control his "Chi" will be able to control the performance of his meridians. He will be able to improve the resonance condition of the meridian and make it a better pass for selected frequency. We therefore checked a Kung-Fu master and compared the pulse shape before and during he released the "Chi". (You may notice that even before he released the "Chi", his meridian performed better and selected the harmonic number 9 strongly.)

As shown in Figures 8-9 and Table 8, releasing "Chi" from

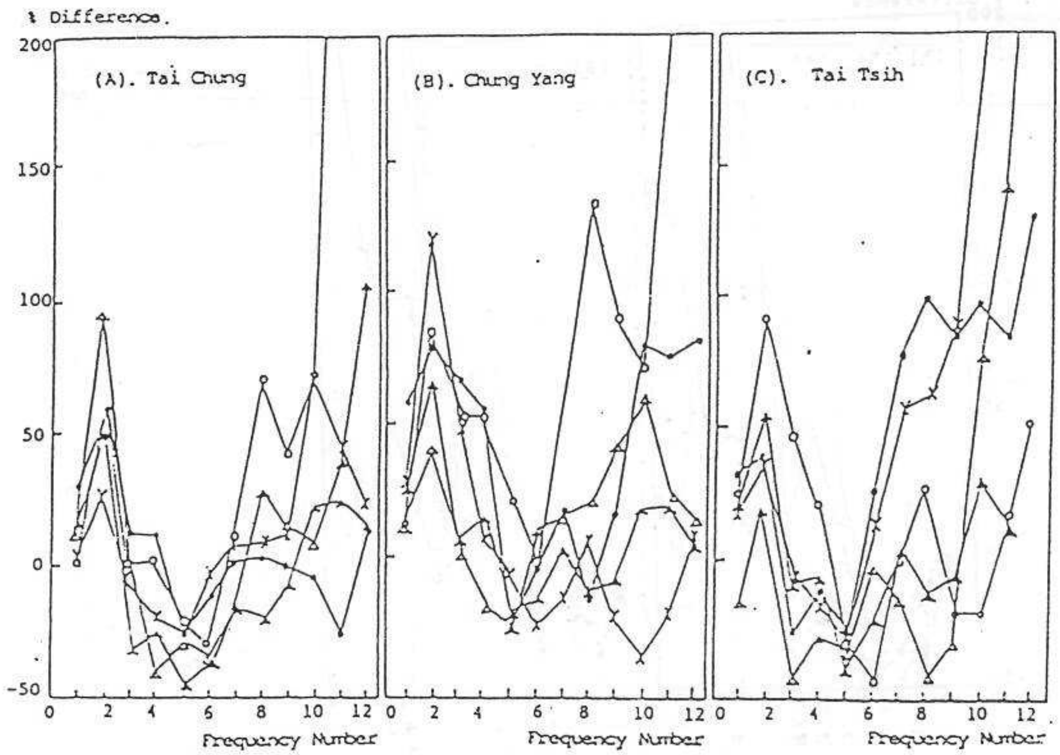


FIGURE 5. The percent difference of the normalized Fourier transformed amplitude of twelve frequencies are shown as 100% $*(C_n' - C_n)/C_n$. ●, x, ⅄, o, Δ represents five different persons. Tai Yuan (C_n) is used as control to compare to:

(A). Tai Chung (C_n')

(B). Chung Yang (C_n')

(C). Tai Tsih (C_n')

the meridian which goes through Hoh Ku would enhance the frequency selectivity. The Fourier component of frequencies numbers 3, 6 and especially number 9, the selected frequency, were enhanced. And it is even more interesting to find that the phase angle is greatly reduced for the selected frequency, so is the attenuation. These all fit well with the prediction by equation (9) and equation (11).

After all these arguments, it becomes comprehensive that the purpose of pulse-feeling at different parts of body is trying to feel more clearly the vibration of the specific frequency which is enriched by different lumped vibrational elements, the meridians. From our previous paper, the internal organs have similar resonance frequencies. Therefore it is possible to correlate these amplitudes from different spots with the resonance condition of different organs.

HOW THE PULSE FEELING IS PERFORMED NOWADAYS?

Nowadays Chinese doctor feels the Tai Yuan (太淵) only. The fundamental assumptions are based on "Nan-ching" (難經). All pulses will appear at this spot.

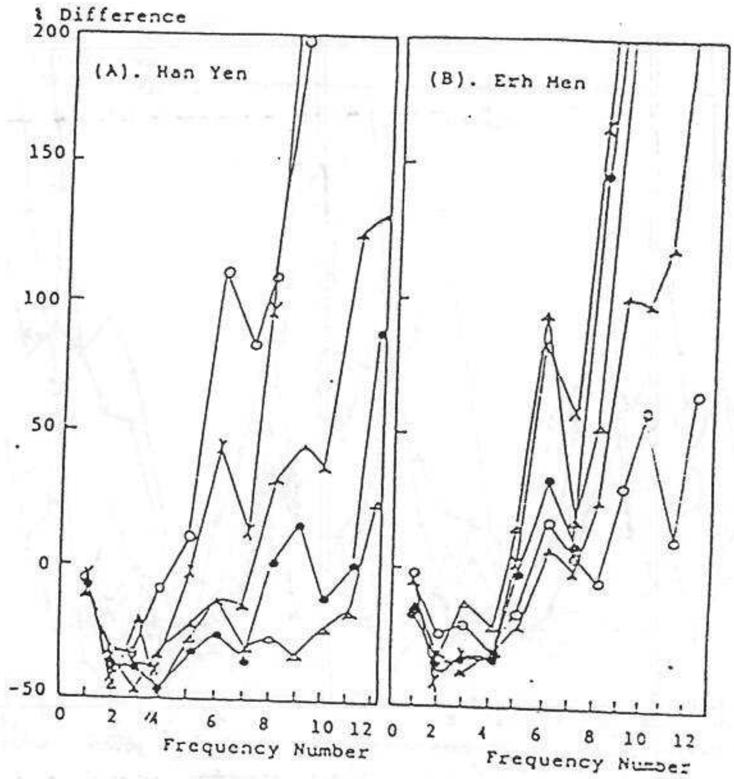


FIGURE 6. The percent difference of the normalized Fourier transformed amplitude of twelve frequencies are shown as 100% $*(C_n' - C_n)/C_n$. ●, x, ▲, o, Δ represents five different persons. Tai Yuan (C_n) is used as control to compare to:

(A). Han Yen (C_n')

(B). Erh Men. (C_n')

Before feeling your pulse, the doctor will let you sit down, adjust your posture, talk with you to make you more relaxed, he will then ask for your wrist, touch the radial artery with three fingers as shown in Figure 10. You may think he is counting the pulse rate, but why use three fingers? According to Chinese medicine, the pulse rate is important. However, the detailed shape of the pulse is even more important. To feel the exact shape of pulse, trainees may spend years to get familiar with the different pulse shapes and their relations to different physical conditions or diseases.

According to "Nei-Ching", the pulse-feeling should be performed in early morning, before meal, exercise or washing. At this very quiet condition, the basic tone of pulse is not disturbed, therefore the pulse will tell us the conditions of the five solid organs as well as the six hollow organs. If it is too strong or too weak, we may then determine the seriousness of the problem and the remedy for it.

" 診法常以平旦陰氣未動，陽氣未散，飲食未進，經脈未盛，絡脈調勻，氣血未亂乃可診有過之脈，切脈動靜而視精明，察五色，觀五臟，有餘不足，六腑強弱形之盛衰以此參伍，決生死之分 。"

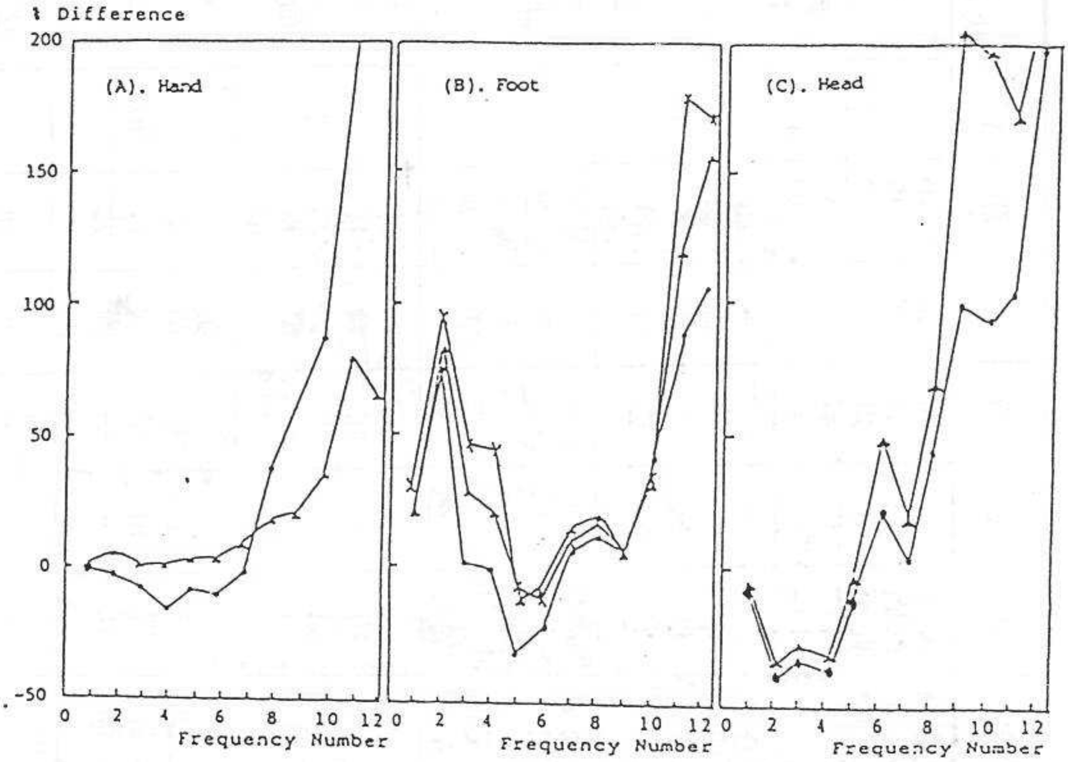


FIGURE 7. The averaged percent difference of five persons, which gives the normalized Fourier transformed amplitude of twelve frequencies shown as AVE ($100\% * (C_n' - C_n)/C_n$). Tai Yuan is used as control (C_n) to compare to other points (C_n').

(A). Two points on head • - Shen Men, ⅄ - Hoh Ku

(B). Three points on foot • - Tai Chung, ⅄ - Chung Yang, x - Tai Tsih

(C). Two points on head • - Han Yen, ⅄ - Erh Men.

So pulse feeling is a very delicate measurement. It must be felt in a very quiet condition. Every experiment must be controlled very carefully not to disturb the delicate resonance of organs with the heart.

(The general shape of the pulse has also been studied thoroughly by Chinese medicine. They are related to the heart condition, the elasticity of artery, the dilation of blood vessel, the amount of blood in arteries and so on. Therefore if you have a fever the general pulse shape will be changed significantly and become over-flooded. If you catch a cold, the general pulse shape will become feeble. All these general shapes have been discussed by many books both in Chinese and Western medicine and will not be discussed in this report.)

This kind of detailed pulse feeling started more than two thousand years ago. In "Nei-Ching", there was discussion about the resonance waves for liver, kidney, spleen and lung.

Modern Chinese medicine books have classified pathology together with remedies with the pulse shape shown in Table 9.

TABLE 9. Some of the standard diagnostic terms and prescriptions.

脈狀 / 脈部		浮	緊	微	數	緩	滑	弦	弱	澀	芤	伏	沉	濡	遲	實	虛
症狀	寸	中風發熱頭痛	頭痛骨肉痛	苦寒爲衄	熱在胃	皮膚不仁風寒在肌肉	胸中壅滿吐逆	心下愊愊微頭痛	自汗出面短氣	胃氣不足	吐血衄血	噎塞不通	胸中引脇痛	自汗出	心痛咽疼吐酸	生熱	生寒
	關	腹滿不欲食	苦滿急痛	心下拘急	胃有客熱	不欲食	胃中有熱、食即吐	胃寒心下厥逆	胃虛有客熱	血氣逆冷	大便下血數升	中焦有水氣溏泄	心下有冷氣苦滿吞酸	虛冷脾熱	胃中寒	胃痛	
	尺	下熱、風、小便難	臍下痛	厥逆小腹中拘急	惡寒臍下熱痛	小便赤黃、腳熱、下腫、小便難、有餘瀝	婦：經脈不利，男：尿血	心腹痛拘急	發熱骨煩	足脛逆冷小便赤	下焦虛、小便出血	小腹痛、癥疝、水穀不化	腰背痛	小便難	下焦有寒	小腹痛、小便不禁	
治法	寸	桂枝葛根湯	麻黃湯	五味子湯	吐法	防風湯	前胡湯	甘遂湯	茯苓湯	地黃湯	竹皮湯	前胡湯	澤瀉湯	乾地黃湯	附子湯	竹葉湯	茱萸丸
	關	平胃丸	茱萸當歸湯	附子湯	知母丸	平胃丸	紫苑湯	茱萸湯	竹葉湯	乾地黃湯	生地黃湯、生竹皮湯	水銀丸	白薇茯苓丸	赤石脂湯	桂枝湯	梔子湯	
	尺	瞿麥湯	當歸湯	小建中湯	鷄子湯	滑石散	朴硝煎、大黃湯	建中湯	前胡湯	附子四逆湯	竹皮生地黃湯	大平胃丸	腎氣丸	瞿麥湯	桂枝丸	當歸湯	

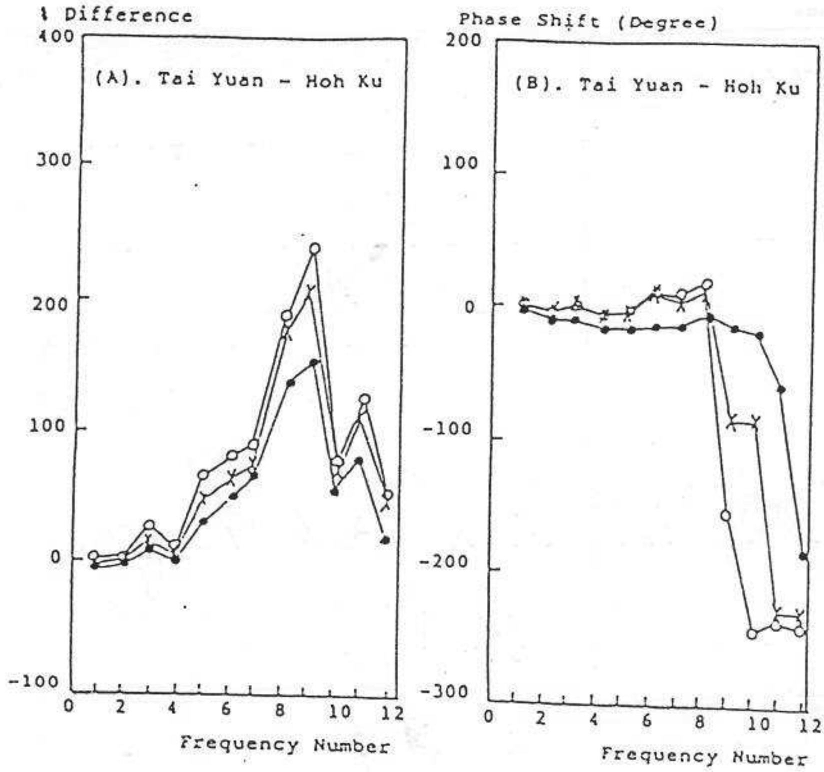


FIGURE 8. The effect of releasing "Chi" through Hoh Ku. • - before release "Chi", x - start release "Chi" about 3 minutes, o - continually release "Chi" about 7 minutes.

(A). The percent difference of the normalized Fourier transformed amplitude of twelve frequencies between Tai Yuan (C_n) and Hoh Ku (C_n') shown as $100\% *(C_n' - C_n)/C_n$.

(B). The phase shift of the 12 frequencies shown as $\phi_n' - \phi_n$. (phase angle of Hoh Ku - phase angle of Tai Yuan)

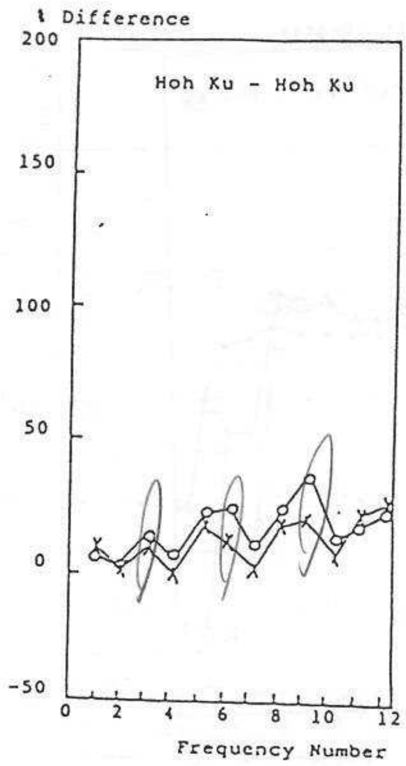
It is a summary of some of the standard diagnostic terms and prescriptions.

The three fingers are put on three specific positions called 寸，関，尺. There are suggestions that the left hand and right hand give information about different organs.

The three positions are related to heart, liver, kidney, lung and spleen, the five solid organs. In some modern text of Chinese medicine, there are also speculations about deep pulse and superficial pulse. The deep pulse is related to solid organs while the superficial pulse is related to the hollow organs.

RELATION BETWEEN PULSE FEELING AND THE ORGAN SPECIFIC WAVE

In "Nei-Ching" and "Nan-Ching" there were thorough discussions about the organ specific waves.



always : 3.6.9

goes up!!

運氣

FIGURE 9. The effect of releasing "Chi" through Hoh Ku. The pulse spectrum of Hoh Ku itself before releasing "Chi" was used as control (C_n) to compare with the pulse spectrum of Hoh Ku during releasing "Chi" (C_n'). The percent difference of the normalized Fourier transformed amplitude of twelve frequencies shown as 100% $*(C_n' - C_n)/C_n$. x - start release "Chi" about 3 minutes, o - continually release "Chi" about 7 minutes.

內經(Nei-Ching)

"春脈者肝也，故其氣來軟弱輕虛而滑，端直以長，故曰弦，反此者病。" "夏脈者心也，………，故其氣來盛去衰，故曰鉤。" "秋脈者肺也，………，故其氣來輕虛以浮，來急去散，故曰浮。" "冬脈者腎也，………，故其氣來沈以搏，故曰營。" "脾脈者土也，孤藏以灌四旁者也。"

難經(Nan-Ching)

"浮而大散者心也，浮而短濇者肺也。" "牢而長者肝也，按之濡，舉指來實者腎也，脾主中州，故其脈在中。"

The translation is:

"The Spring pulse is dominated by liver, ...,. The "Chi" is soft and smooth, long and straight. So we say it is like a string. If not, you are sick."

"The Summer pulse is dominated by the heart, ..., The "Chi" comes strong but goes weak. So we say it is like a hook."

"The Autumn pulse is dominated by the lung,.... The "Chi" comes soft and floating. It comes fast then spreads. So we say it is floating."

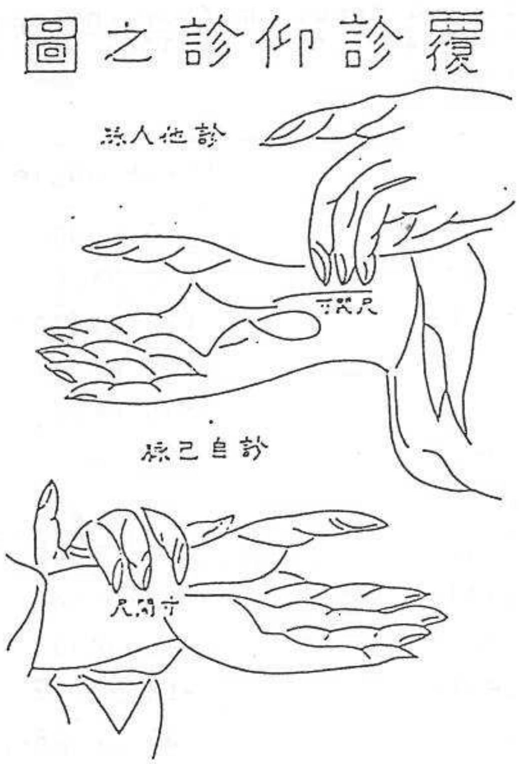


FIGURE 10. Chinese pulse diagnosis, Sung dynasty. After the Yellow Emperor's Classic of Internal Medicine.

"The Winter pulse is dominated by kidney,.... The "Chi" comes as strong as a stone. So we say it is like a falling stone."

"The spleen is the lonely central organ that irrigates the surrounding."

In the "Nan-Ching"

"Floating and spreading is the heart pulse."

"Floating but slurring is the lung pulse."

"Enduring and lasting is the liver pulse."

"When pressed it is soft, but when you raise the finger, it comes strong. This is the kidney pulse."

"Spleen is the central organ, so the pulse is right at middle."

All these documents seem to tell us the heart Chi comes at the beginning of the pulse. It comes strong then disappears. The lung wave also comes at the beginning of the pulse but stays as a train of short waves. The liver wave is long. It stays longer than that of the heart. The kidney wave is weak at the beginning, and suddenly comes out at the last part. The spleen wave is right at the center of the pulse.

From the organ specific resonance waves we found in our pre-

TABLE 10. The Fourier transformed spectrum from the pulse of a normal person. The normalized amplitude is 100% * C_n/C_0. The unit of phase angle is degree.

n	Amp (C_n)	Nor. Amp	Phase Angle
0	1766.34277	100.00000	0.00000
1	1505.68213	85.24292	102.34065
2	876.61273	49.62869	137.17479
3	399.75214	22.63136	179.60005
4	296.97833	16.81318	-172.97724
5	191.11801	10.81998	-124.90088
6	81.61549	4,62059	-98.57288
7	48.29361	2.73410	-88.55642
8	29.18774	1.65244	-67.01342
9	14.31484	0.81042	-41.34580
10	4.60961	0.26097	-18.09173
11	5.51830	0.31241	-59.12928
12	1.47808	0.08368	-27.30604

n: frequency number.

Amp: amplitude

Nor. Amp: Normalized amplitude

vious paper, we can actually synthesize these harmonics back to the whole pulse. From the synthetic process, we may understand why Chinese medicine use the specific spots of 寸, 關 or 尺 to diagnosis the condition of a specific organ.

It is understandable that the heart is related to C_0 in Table 10. It is the total cardiac output. In the pulse it is related to the height of the pulse that appears at 寸. To study the property of other organs, we will remove its specific resonance frequency then put it back to see its effect on the pulse shape.

Figure 11 is an example. The pulse was synthesized from the first twelve harmonics shown in Table 10. There is no detectable difference with the real pulse.

When we remove the first harmonic out of it, the shape is like Figure 12(A). This is the pulse shape without the liver wave or in chinese term "the dead liver pulse". In "Nei-Ching", " 死肝脈來急益勁如新張弓弦 " which means the dead liver pulse comes very strong like a string of a newly finished bow. There is further explanation "the newly finished string is too strong and without the stomach wave." The stomach wave is at the middle of pulse. This seems to fit the Figure 12(A) very well. In Figure 12(A) the pulse lasts very long but without the middle part. If we

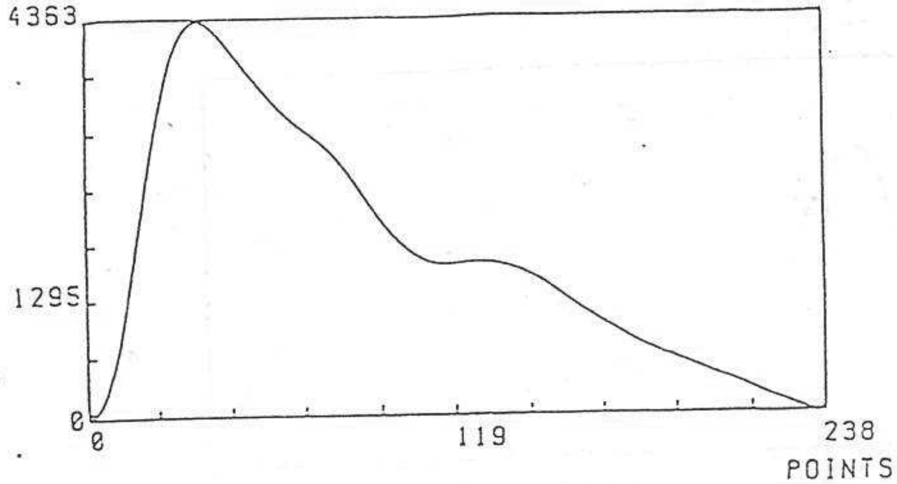


FIGURE 11. The synthetic pulse from the twelve harmonics on Table 10, which is almost no difference with the original pulse, its period is T = 238 points * time units/point.

compare Figure 12(A) with Figure 11 as shown in Figure 12(B), it is clear that the greatest difference come right after the peak of the pulse as indicated by arrow. Or in chinese term it is somewhere between 寸 and 關 .

When we remove the second harmonic from the pulse, the shape is shown in Figure 13(A). This is the pulse shape without the kidney wave or in Chinese term "the dead kidney pulse". In "Nei-Ching", " 死腎脈來發如奪索辟辟如彈石曰腎死 which means "The dead kidney pulse comes like a wave traveling along a very tensed rope. It also like the stone that bounds from the ground.". It is understandable that along a very tensed rope the wave will be strangled and travel in a strange way. The falling stone that bounces back from the ground is the like later half of the pulse. The pulse reaches the ground then bounces back with a much lower amplitude. This description seems to fit Figure 13(A) very well. When we compare Figure 13(A) with Figure 11 as shown in Figure 13(B), the largest difference comes from the last one third or in Chinese term the 尺 of the pulse.

When we remove the third harmonic from the pulse, the shape is shown in Figure 14(A). This is the pulse shape without the spleen wave or in Chinese term "the dead spleen wave". In "Nei-Ching", " 死脾脈來堅如鳥之喙，如鳥之距，如屋之漏水，如水之流 "which means "The dead spleen pulse is as hard as the bird's beak. It is fast like the moving talon. It is random like the leaking roof. It spreads like the running water.". In other works, it becomes very irregular, hard and there are small random peaks wondering all around. This description seems fit well with Figure 14(A). When we compare Figure 14(A) with Figure 11 as shown in Figure 14(B), the largest difference could be from the first one third of the pulse or the last one third of the pulse. But the first one third has been assigned to liver, the last one third has been assigned to kidney, both have even larger variation there. Therefore, only the middle part peak is still feas-

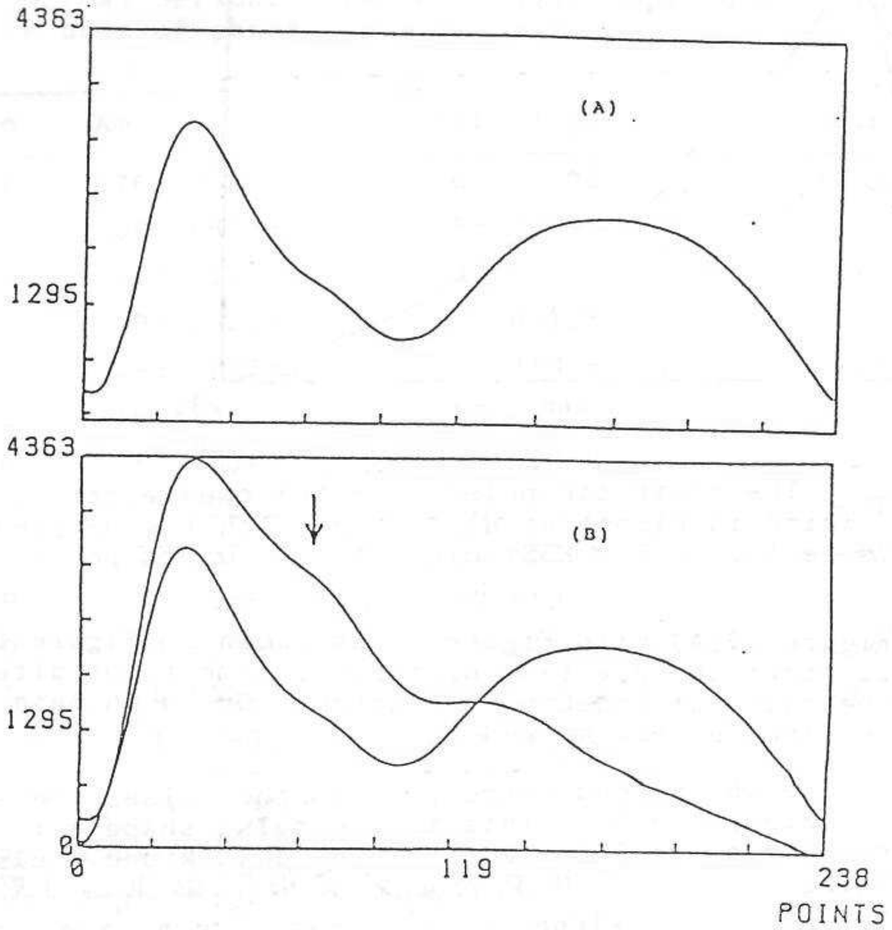


FIGURE 12. Comparing the complete synthetic pulse with the first harmonic absent pulse.

(A). The synthetic pulse without the first harmonic $C_1 * \cos(2\pi t/238 - \phi_1)$.

(B). The arrow indicates the most significant place between the complete synthetic pulse and the first harmonic absent pulse.

ible to represent the spleen wave or in Chinese term "the 關 part".

When we remove the fourth harmonic from the pulse, the shape is shown in Figure 15(A). This is the pulse shape without the lung wave or in Chinese term "the dead lung wave". In "Nei-Ching". " 死肺脈來如物之浮，如風吹毛 " which means "The dead lung wave is like a floating subject. It also like the wind blowing over a fur.". In Figure 15(A), the pulse shape is actually like a floating subject which regularly bounce up and down. It is also like the wind blow over a fur. The wave disappears gradually. When we compare Figure 15(A) with Figure 11 as shown in Figure 15(B), the largest difference comes before the peak of the pulse. Therefore, we may possibly sense its amplitude by feeling the spot of 寸, and feel the movement right before the peak (the heart pulse).

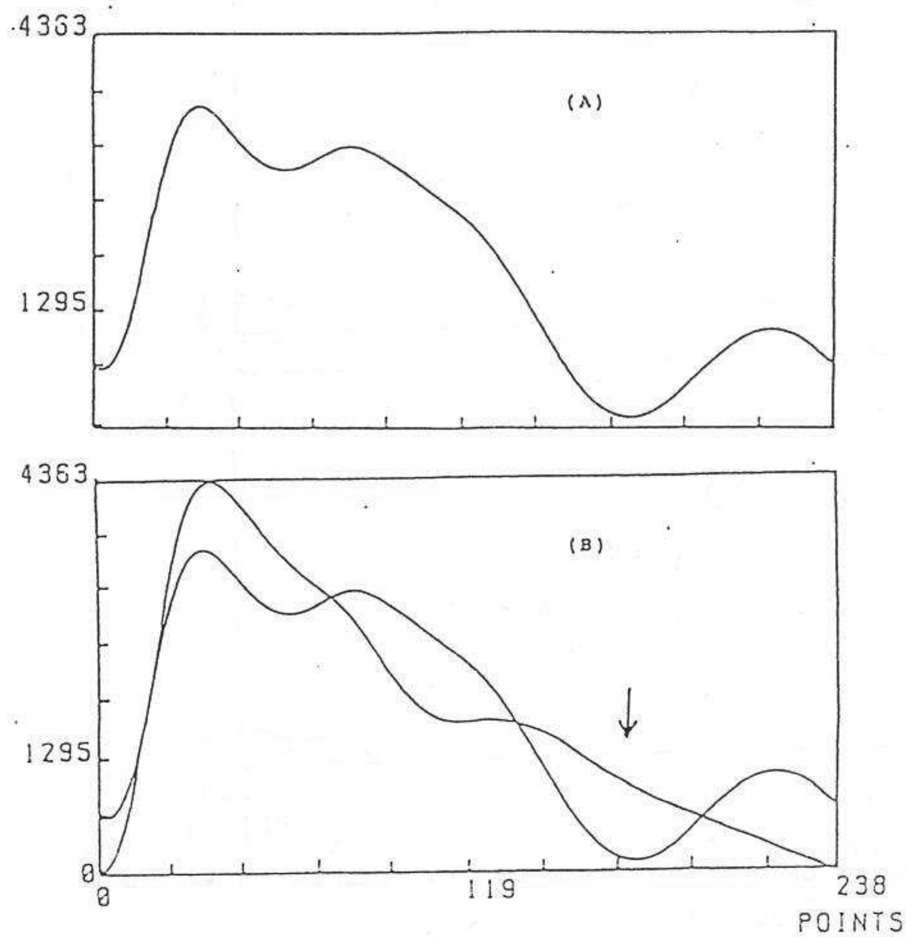


FIGURE 13. Comparing the complete synthetic pulse with the second harmonic absent pulse.

(A). The synthetic pulse without the second harmonic $C_2 * \cos(2\pi * 2t/238 - \phi_2)$

(B). The arrow indicates the most significant place between the ocmplete synthetic pulse and the second harmonic absent pulse.

From what we have discussed, it seems that ancient Chinese might have known the organ specific resonance wave for more than two thousand years and developed a simple systematic way to examine it.

In "Nei-Ching" there is also a statement "臟者爲陰，腑者爲陽" which means solid organ is female, hollow organ is male. In Chinese term female also means less movement, male also means more. In "Nan-Ching" there is "數者腑也，遲者臟也" which means that solid organs move slowly however hollow organs move fast.

Our experimental results seem also confirm these statements. The solid organs are in resonance with the lower harmonics of the heart beat while the hollow organs may be in resonance with the higher harmonics of the heart beat. We are currently investigating the hollow organ specific resonance wave. It

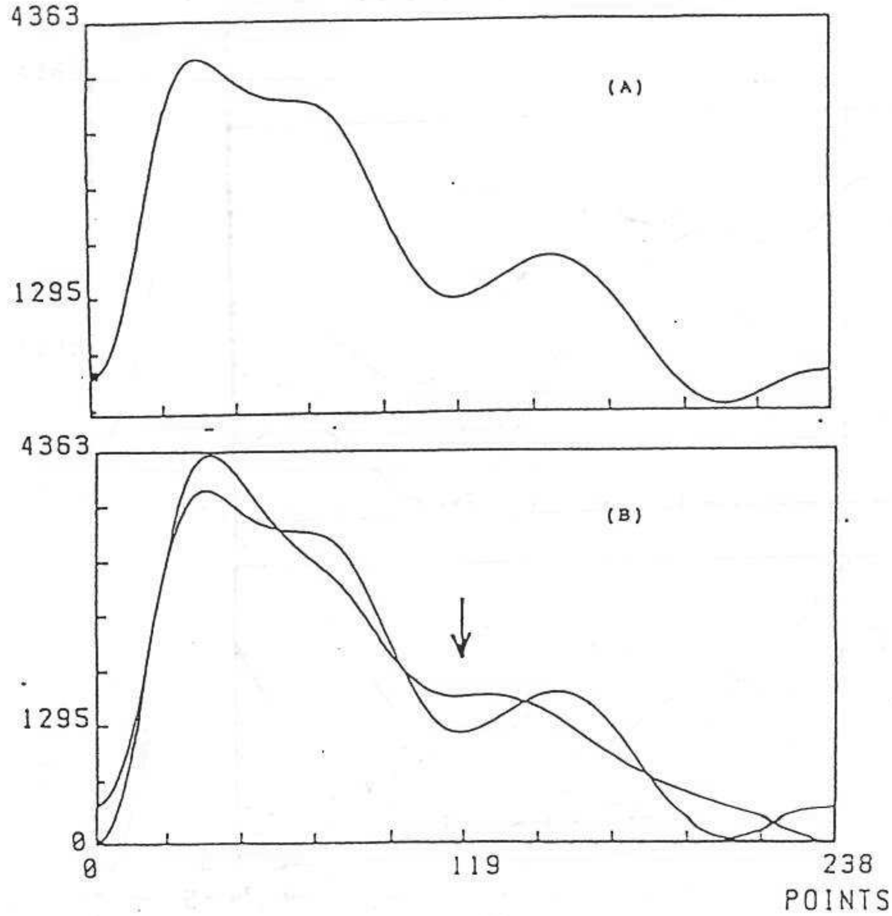


FIGURE 14. Comparing the complete synthetic pulse with the third harmonic absent pulse.

(A) . The synthetic pulse without the third harmonic C_3 $*\cos(2\pi * 3t/238 - \phi_3)$

(B) . The arrow indicates the most significant place between the complete synthetic pulse and the third harmonic absent pulse.

also becomes understandable why some modern Chinese medical books also assign some superficial pulse feeling to the hollow organs, this is because their resonance waves are of higher frequencies with much smaller amplitude.

CONCLUSIONS

In all these derivations we have assumed that we may treat each frequency as a separate component. The pressure amplitude of each specific frequency will determine the flow rate of blood that enter its resonant organ.

Ancient Chinese somehow understood the importance of this mechanism and realized that when body is quietly at rest, these fundamental frequencies of organs can be vividly felt.

Actually this kind of frequency specified blood distribution

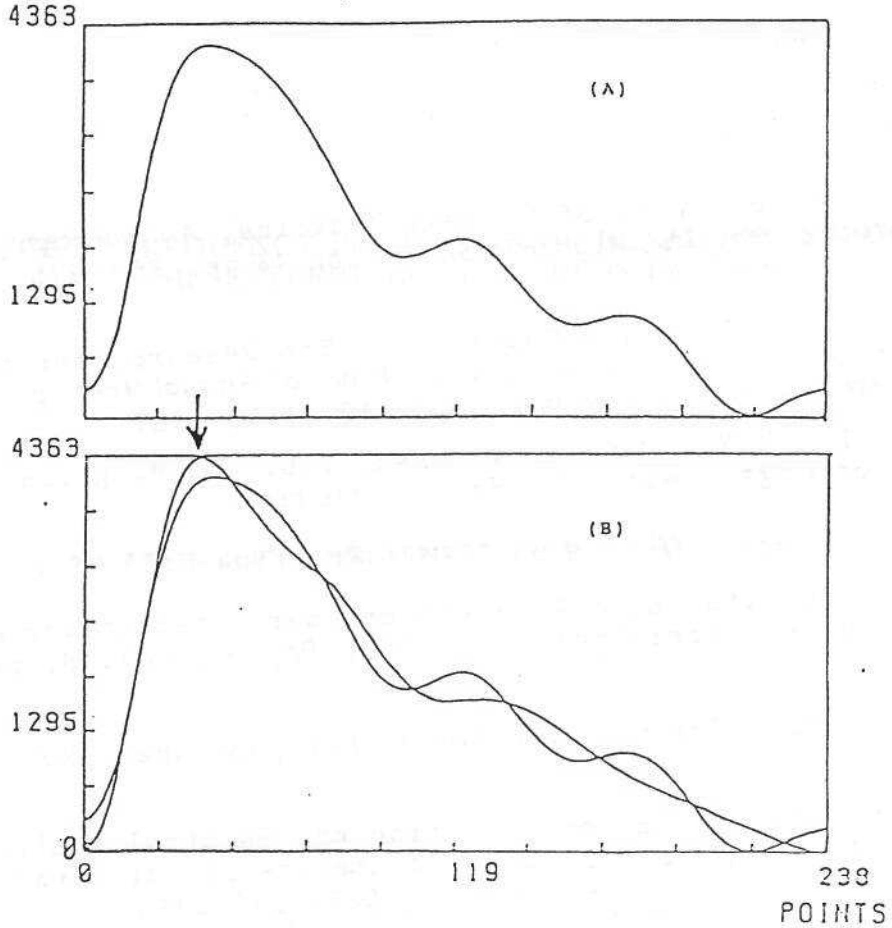


FIGURE 15. Comparing the complete synthetic pulse with the forth harmonic absent pulse.

(A) . The synthetic pulse without the forth harmonic $C_4 * \cos(2\pi * 4t/238 - \varphi_4)$

(B) . The arrow indicates the most significant place between the complete synthetic pulse and the forth harmonic absent pulse.

is controlling not only the body blood distribution but also the redistribution. The mechanism of the so called "Times of maximum energy" (子午流注), or "mother and son law" (五行相生相尅) all can be understood. Most fundamental principles of acupuncture could also be deduced if we study the body frequency distribution and construct more detailed model of meridians by giving each acupuncture point some unique property.

Finally, we wish to emphasize that the pulse feeling is the foundation of most theories in Chinese medicine and we will use some modern terms to describe it: The pulse feeling is an infrasonic wave detecting the structural and functional conditions of your organs. The waves propagate in the artery and arterial trees, while the heart is the wave generator, and the three fingers are the transducers.

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