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Past, Present, and Future of the Pulse Examination (脈診 mài zhěn)

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Abstract

The pulse examination (脈診 mài zhěn) is a unique diagnostic approach of Traditional Chinese Medicine. The description of pulse examination in the history of Traditional Chinese Medicine is full of amazement and mythology. After researching in hemodynamics and investigating in clinical application for three decades, this article describes the development and the merits and demerits of pulse examination. The experiences of the ancients are tried to be illustrated with modern knowledge and language. As the theory of resonant blood circulation is discovered, Traditional Chinese Medicine could be on the shoulder of Newton and then lead the development of modern medicine. Hope the tool of pulse examination constructed according to eigen-vector with specific time domain and position can bring the running water for Traditional Chinese Medicine. Quantitative research could overcome the plight of analog logic qualitative research, and therefore bring new health revolution.

Key words: Eigen-vector, Harmonic, Spectrum, Meridian, The *Inner Canon* (內經 nèi jīng)

Foreword

The pulse examination (脈診 mài zhěn) is the symbol of Chinese medicine and also one of the features of Chinese medicine. In many writings related to Chinese medicine, the plus-taking-with-three-fingers are always considered as an important diagram. And, whenever Chinese medicine is mentioned, the image of plus-taking-with-three-fingers will come to most people's mind. Among the four examinations (also translated as 'four diagnostic methods') in Chinese medicine, the methods of inspection, listening and smelling, and inquiry have been further developed in modern medicine. Especially, regarding the method of inspection, many technologies have been rapidly developed for modern medical imaging, including X-CT, MRI, PET and ultrasonography. And the endoscopy units, such as gastroscopy, colonoscopy, enteroscopy, as well as microscope have been all kept improved so that the scope of the method of inspection has been enlarged and becomes a medical philosophy of 'seeing is believing'. The method of listening and smelling has been developed by means of blood test and urine test, which are very convenient and affordable and therefore become basic information in all kinds of modern diagnostic.

Under the background, we start our investigation of pulse examination because, on the one hand, it is the only diagnostic method in Chinese medicine that has not yet been understood and explored in modern medicine and, on the other hand, it's our goal to further understand this valuable door to Chinese medicine.

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The Past of the Pulse Examination

According to the written history, the pulse examination is first seen in the 1st Year of Zhao Gong in the *Zuo Zhuan* (also translated as *Chronicle of Zuo*), in which documented a story about Qin Gong who sent Qin He to diagnose and treat the marquis Jin and then Qin He adopted the method of correlation of complexion and pulse to analyze his disease. The note of the *Rites of Zhou* further describes that 'the major method to take the pulse is the wrist pulse-taking at Yang Ming, and the one who is good at this method is Qin He'. In the *History of the Later Han*, there is also a story about Pei Weng who was good at feeling the pulse and wrote a book about pulse examination and a story about Guo Yu who had great knowledge about 'the skill of diagnosing of tiny acupoints and the art of changes between yin (陰 yīn) and yang (陽 yáng)'.

The other documents unearthed by the archaeological discoveries, such as '*Quicksand Falling Record Slips*', '*Wuwei Han Dynasty Record Slips*', and '*52 Prescriptions* (五十二病方 wǔ shí èr bìg fāng)' are the writings earlier than the *Neijing* (also translated as *Inner Canon*) but their author were unknown. The writing that was more systematically recorded is the pulse examination of physician Bian Que, who was also named Qin Yue Ren. The 'Collected Biographies of Bian Que and Cang Gong in *Shiji* (also translated as the *Records of the Grand Historian*)' describe that 'the most famous physician knowing well pulse-taking is Bian Que'. The *Huainanzi* (literally as *The Masters/Philosophers of Huainan*) also describes that he could give an appropriate prescription according to illness and diagnosed the causes of illness according to the complicated pulse.

The era of Bian Que is partially overlapped with that of the *Inner Canon* and some writings are similar to or entirely the same as the *Inner Canon* but some writings are different, such as the Ten Strange Pulses (十怪脈 shí guài mài). The most obvious difference between Bian Que and the *Inner Canon* is that the *Inner Canon* includes the 'pulse examination of twelve meridians' and the 'three parts and nine indicators (三部九候 sān bù jiǔ hòu)' but Bian Que's pulse examination is only about the 'exclusive examination of the inch opening (wrist pulse)'.

Bian Que attached particular importance to the changes in the pulse during a day or a year. Therefore, he proposed the principle of yin-yang pulse examination. He emphasized the regular patterns of temporal changes in three yin pulses (三陰脈 shí guài mài) and three yang pulses (三陽脈 sān yang mài) and also observed the correlation between body types and pulses. Cang Gong, originally named Chun Yu-yi (淳于意 chún yú yì), a disciple-successor of Bian Que, also advocated the 'exclusive examination of the inch opening (wrist pulse)'. According to his classification, there were twenty-two types of pulses, including floating pulse, sunken pulse, string-like pulse, rough pulse, tight pulse, slippery pulse, rapid pulse, hard pulse, replete pulse, long pulse, large pulse, scant pulse, weak pulse, normal pulse, chattering pulse, tranquil pulse, agitated pulse, dissipated pulse, intermittent pulse, foreign yin, foreign yang, and drag-over ming. Besides, the later generations often referred to his insights on febrile disease. For example, he considered that drag-over Yang pulse was the intermingling of yin and yang and the most threatened illness of double contraction and described it as 'heat relapses after sweating, agitated racing pulse and incessant sweating, manic raving with inability to eat.' As to drag-over yin pulse, he described it as 'recovering with normal and clear pulse'. His insights were used in other classics, such as the "Plain Questions, Treatise Discussing Heat Disease" and Zhang, Zhong-jing's *Cold Damage* 'the first day of cold damage is the cold damage of tai yang and if the pulse is tranquil, it is non-passage.'

Although Cang Gong thought that none of the four examinations was less important than the others, he stressed particularly the method of pulse examination as he mentioned 'so many similar diseases difficult to be known, that's why the ancient sages adopted the method of pulse-taking. It's a measurement and a rule to balance, to regulate and adjust yin and yang. The pulses of human body were named according to the rules of heaven and earth. Meanwhile, by considering an individual's constitution, we could tell hundred diseases.'

He not only referred to many ancient medical documents, such as pulse examination, pulse examination principles, diagnosis (診法 zhěn fǎ), and odd cough, but he also had some outstanding disciples, such as Song Yi, Du Xin, and Tang An, who had contributed much to the succession of the knowledge of pulse (脈學 mài xué).

According to the documents '*Central Treasury Canon* (中藏經 zhōng zàg jīng)', '*Divine Physician Hua Tuo's Secret Tradition*', 'Ways to observe visceral pathological changes', we could know that Hua Tuo's (華陀 huà tuó) pulse examination method was inherited from Bian Que, that is, his diagnostic method was also 'exclusive

examination of the inch opening (wrist pulse)'. For the first time, corresponding relation between the 'inch, bar, and cubit' and the various organs were noticed, such as the heart, the small intestine at left inch, the liver and gallbladder at left bar, the kidney at left cubit, the lung at right inch, and the spleen at right bar. As for the other parts, no documents were available for reference.

When Cang Gong adopted the 'exclusive examination of the inch opening (獨取寸口 dú qǔ cùn kǒ u, wrist pulse), he didn't tell the difference between 'inch, bar, and cubit' and he pressed with two or three fingers jointly. And, his pressing method included only floating pulse and sunken pulse. Until Hua Tuo, he proposed the method of 'three fingers and three parts', that is, we could press with three fingers jointly or with one finger singly. The "pulse examination about organs" had been well developed. As to the organs not indicated, it is believed that the related documents might have been lost. Hua Tuo also proposed the 'pulse examination with eight principles', including yin and yang pulses, exterior and interior pulses, cold and heat pulses, and vacuity and repletion pulses, as an equivalent work to the 'pulse examination about organs'.

The pulse examination of the *Inner Canon* originated from one school of the 'medical classics (醫經 yī jīng)'. The *Inner Canon* is the first written record among the 'medical classics' handed down to the later generations until today and it is the most important work among the medical classics. It not only integrates the ancient pulse examinations, such as the sphygmology theory of Bian Que, that of Cang Gong, and that of Hua Tuo, but it also plays the role as successor of the past and as pioneer of the later generations and it still works as the basis of the backbone of Chinese medicine.

The content of the *Inner Canon* is the collection and collation of the relevant medical knowledge during the Warring States Period and the Qin and Han Dynasties. The main structure is composed of 'yin and yang', 'five phases (五行 wǔ xíng)', 'organs (臟腑 zàng fǔ)' and 'meridians (經絡 jīng luò)' and forms a thoroughly integrated classic work that no others have surpassed today. Regarding the discourses of sphygmology theory, however, there were no consistent arguments in respect of the principles, methods, pulses and main diseases so that an inclusive way was adopted to deal with those issues.

In the *Inner Canon*, the <Plain Questions, Treatise on the Three Parts and Nine Indicators> was actually the result of the evolution and development of the pulse examination of twelve meridians. The sphygmology theory of the *Inner Canon* is based on 'yin and yang' and considers the 'meridians' as blood vessels. It considers the blood passes through the 'twelve meridians' (rather than the 'blood vessels' commonly called today) so that a pulse examination is to inspect and diagnose the distribution of blood inside a human body. For example, the normal one is called as 'normal pulse (平脈 píng mài)' and the unusual one is called as 'morbid pulse'. In the perspective of the *Inner Canon*, it is clearly stated that a pulse examination is to inspect the 'meridians'. For the examination of the 'meridians', we could inspect directly the points of artery on the 'meridians' and we also could distinguish the 'twelve meridians' or 'three parts and nine indicators' through the artery at the inch opening (wrist pulse). It is also the basis on which the pulse examination has been developed by the later generations. And, the *Pulse Canon* (脈經 mài jīng) by Wang, Shu-he (王叔和 wáng shū hē), which includes the theory about the inch opening divided into nine ways and that about the subordinate meridians belonging to 'inch, bar, and cubit (寸關尺 cùn guān chǐ)', becomes the mainstream of sphygmology in the later generations. However, for Zhao, En-jian, a modern great sphygmology master, 'one of the major problems is that there was no succession or development of the ideas, methods and contents of the generalized examination of the whole body. And, that is the main reason why pulse examinations were not greatly developed by the later generations. Otherwise, a generalized examination of the whole body should have been significantly developed; for such a long time and through such a large number of practices, the method of 'palpation' should have been completely developed in all aspects; and, for these two thousand years, in the practice of Chinese medicine, the touch parts should not only have been focused on the radial artery while inspecting a patient'. (Chao, 1988)

Summary

As for the old documents about pulse examination, the *Inner Canon* had completely collated their main contents so that the later physicians only took the summarized parts in the framework of the *Inner Canon*. Some parts were somehow further developed but some parts got lost. Such a phenomenon is frequently seen in the development of Chinese culture. Until the modern time, there have been always some people, just like Wang Mang of the New (Han) Dynasty, who advocate everything should return to and follow the ancient classics and culture. It's the same as Chinese medicine; some people also advocate everything should return to

and follow the medical knowledge documented in the *Inner Canon* and the classical remedy of Zhang Zhong-jing and other ancient physicians.

After a review, in all aspects, of the features of Chinese culture, a very interesting viewpoint is found.

Logic system of Chinese culture is always about analogy. All 'yin and yang', 'five phases', 'I Ching Hexagrams' and 'twenty-eight pulses in pulse examination' had been developed their qualitative description according to the method of analogy and been mostly described in text. We find not only the operational definition but also the concept of quantization was absent. An ancient at that time, probably Bian Que or a genius of earlier era, found the functions of the human body could be explained by analogy with 'yin and yang', 'five phases', metal, wood, water, fire, and earth. Meanwhile, another genius found the phenomena of astronomy and four seasons could be explained by analogy with metal, wood, water, fire, and earth. What an earth-shattering discovery!

Within Chinese culture, the harmony between man and nature has been greatly advocated. According to the *Inner Canon*, within the human body we could find the existence of a small universe of heaven, earth and man. It is a work exemplifying Chinese culture.

We reviewed this logic system of analogy, that is, all things in the whole world could be explained by 'yin and yang' and 'five phases' and then we got an idea.

Among the things in the world that have been recorded, most of them are periodic. That's because the non-periodic things or matters had flashed off and we have not had another chance to observe them. Accordingly, we have not had chance to obtain a detailed record about them. Therefore, it will be difficult to be kept in our history and culture.

The sunrise, sunset, change of four seasons, cycle of astrological phenomena and so on were all clearly observed by and known to the ancient civilizations around the world. That the Egyptians worshiped the sun or that the Mayan people understood astrological phenomena and could predict the date of occurrence of a solar eclipse or a lunar eclipse thousands of years later are obvious examples. And, the Chinese, Mayan, Egyptian civilizations all have their perpetual calendar. What a great achievement!

Within the ancient Chinese culture, the ancients created 'yin and yang' and 'five phases' to describe the relationship between all things in the world. At first glance, this five-element culture seems quite the same as the four-element culture of Greece or the six-element culture of the Hebrew, but what is more interesting is that the 'mutual engendering and subduing' derived from the five-element culture could be explained by the harmonic waves that were composed of periodic signals.(Wang 2002, Wang et al. 1989)

About 70% to 80% of this five-element culture of 'mutual engendering and subduing' could be explained by the relationship of 'mutual engendering and subduing' between the harmonic waves.

With 70% to 80% of correctness, workable for all periodic things, it was used in the *Inner Canon* to explain the cyclical phenomena in physiology, that is, the features of pulse waves. Because the heart has been repeatedly beating, the pulse waves accordingly generated could be described by the 'mutual engendering and subduing' of 'five phases' to achieve 70% to 80% of correctness. It was really a great achievement during the era in which physiology was still unknown.

Therefore, within Chinese medicine, the various theories derived from the logic system of analogy allowed our ancients to tell the types of diseases and determine the treatments directly without the help of anatomy or physiology, without understanding cytology or the functions of each organ, and without having any knowledge of the distribution of endocrine, nerves or blood vessels. It is the power of the logic system of analogy! And, it is the great wisdom of the ancient sages!!

However, the analogy relationship not only lacks the total accuracy but also presents only the similarity of an analog. The biggest drawback of the logic system of analogy is the lack of quantified data. Because of lack of analysis of quantified data, no accurate verifications could be carried out. The ancient sages realized this great analogy relationship two or three thousand years or more years ago. If the later generations still limited their ideas in this analogy relationship, they would never start the work of verification using quantified data only because they limited their understanding or they wanted to expand the scope of application without taking consideration the overall situation. That's why the righ ways, evil ways, truths and lies all have been present in the documents since the Qin and Han Dynasties.

What on Earth Does the Pulse Examination Inspect?

1. Twelve meridians on the whole body:

A) Pulse examination of twelve meridians: a method

to choose an emerging or relatively emerging pulsating vessel that is exemplifying or easy to be inspected, among the twelve meridians, including three yin channels of the hand, three yang channels of the hand, three yin channels of the foot, three yang channels of the foot, to inspect the pulsating vessel (vessel qi). The exact locations are as follows:

Great Abyss (太淵 tài yuān): lung, inch opening (wrist pulse).

Yang Ravine (陽溪 yáng xī): large intestine, union valley of the hand.

Surging Yang (衝陽 chōng yáng): stomach, dorsum of the foot.

Surging Gate (衝門 chōng mén): spleen, front and rear groove joints at the bottom of the belly.

Yang Pore: heart, inside Spirit Gate.

Celestial Window (天窗 tiān chuāng): small intestine, beside the throat.

Bend Center (委中 wěi zhōng): bladder, bent part of the back of the knee.

Great Ravine (太溪 tài xī): kidney, side point on the inner face of the ankle.

Palace of Toil (勞宮 láo gōng): colorful network vessel, palm heart.

Harmony Bone-Hole (和髎 hé liáo): triple burner, between the eye and the ear.

Suspended Bell (懸鐘 xuán zhōng): gallbladder, on the outer face of the ankle.

Supreme Surge (太衝 tài chōng): liver, upper surface of the great toe of the foot.

In the early stages of the creation of pulse examination, the diagnoses were carried out through the twelve meridians on the whole body.

In the history of the development of Chinese medicine, the most mysterious part is the twelve meridians. Among the earliest written records, i.e. the document unearthed at Mawangdui, we could find the eleven channels, except for heart channel. Until the *Inner Canon*, we could find all the twelve meridians. It's unlike the pulse examination or prescriptions, of which the development process could be traced through the documents.

The generalized examination of the whole body through the twelve meridians is more comprehensible. The purpose of the pulse examination is to understand the distribution of qi and blood (pulse) inside the twelve meridians on the whole body. Therefore, if the distribution is found particularly large or small, it must be a sign of disease. The distribution should be uniform or even, the pulse could be determined as a normal pulse, i.e. a regular pulse. In the perspective of the idea of the *Inner Canon*, the pulse examination is to inspect the distribution of blood inside the channels and diseases could generate uneven distributions inside the twelve meridians. Therefore, the pulse examination is to diagnose the health condition of the meridians. Besides, the twelve meridians belong to yin, i.e. the geometric structure of the distribution of blood; and, the pulses belong to yang, i.e. the vibrations generated by the blood flows inside the twelve meridians. After having understood the principles of the pulse examination, we could understand the meridians; on the contrary, if we could make a breakthrough in the study of the meridians, we could understand the pulse examination. They are the both sides of the same integrated body.

2. Three parts and nine indicators:

B) Pulse examination of three parts and nine indicators: as for this method, please refer to <Plain Questions, Treatise on the Three Parts and Nine Indicators>. The exact locations are as follows:

Heaven at upper part: the arterial of the cheeks, foot lesser yang channel (少陽經 shào yáng jīng) on the both sides of the forehead.

Earth at upper part: the arterial of the cheeks, on the both sides of the nose closer to Great Bone-Hole yang brightness channel.

Man at upper part: the arterial in front of the ears, hand lesser yang channel at the sunken part in front of the ears.

Heaven at central part: hand greater yin, inch opening (wrist pulse).

Earth at central part: hand yang brightness, union valley.

Man at central part: hand lesser yin, spirit gate.

Heaven at lower part: foot reverting yin, the sunken part that is one-inch outside pubic hair region and under sheep bar, about five li and find it at prone part; for the females, take great thoroughfare, i.e. the sunken part that is two-inch behind the base joint of the great toe of the foot.

Earth at lower part: foot lesser yin, at the sunken part of the anklebone on the inner side of the foot, great ravine.

Man at lower part: foot greater yin, on fish belly (魚腹 yú fù) and between rush sinews, under rigid five li and about winnower gate (箕門 jī mén); find it by loosening the feet, with simple clothing and feeling the deep level; after examining stomach qi, find it on the upper surface of the foot and about surging yang.

The *Inner Canon* goes to great length to show the 'Three parts and nine indicators'. Many modern physicians consider it's actually the same method as the pulse examination of twelve meridians and it's also a generalized examination of the whole body and it does not have much specific meanings.

3. Inch, bar, and cubit (寸關尺 cùn guān chǐ):

Taking pulse on radial artery has been always the symbol of Chinese medicine. The wrist pulse-taking method began as early as Bian Que's era. The organs had been clearly classified as early as Hua Tuo's era. For example, left inch included heart and small intestine, left bar included liver and gallbladder, left cubit included kidney; right inch included lung, right bar included spleen. Stomach pulse was classified as over-bar but the specific position of over-bar was not indicated. In the later generations, however, a slight difference appeared but the principal structure was generally maintained, always on the basis of Hua Tuo's classification. The relationships between `left inch, left bar, left cubit, right inch, right bar, right cubit' and organs were collated in respect of the important ancient documents as Table 1.

After the construction of the tool of pulse examination from 1988 to 1990, we had carried out many partial measurements, specified at inch, bar, and cubit. The sensors were respectively installed at the positions of 'inch, bar, and cubit', or at the position a little more in front of 'inch' or a little more in back of 'cubit'. The pulses obtained from the left hand were within the margin of error, in other words, they were almost with the same value. And, the pulses obtained from 'inch, bar, and cubit' of the right hand showed the same result, that is, they were almost the same.

This result is somewhat unexpected. In the perspective of hemodynamics, however, it seems inevitable. That's because when the blood in the arteries moves from the proximal end of heart to the remote end of heart, both blood pressure wave and blood fluid wave are continuous, and how could a significant change occur in such a section of blood vessel less than 5 cm? Unless a significant change at the positions of "inch, bar, and cubit" is presence in such a section of artery or surrounding tissues. In order to save Chinese medicine, some people proposed a fractal theory and considered that this small section of blood vessel and its surrounding tissue can reflect the structure of the other parts or organs of the human body. But both for the normal and ill persons, no specific change is found in this small section of blood vessel and its surrounding

Table 1. The relationships between 'left inch, left bar, left cubit, right inch, right bar, right cubit' and organs Name of work

Name of work		Inch		Bar		Cubit	
		Left	Right	Left	Right	Left	Right
The *Inner Canon*	Inner	heart	lung	liver	stomach	kidney	kidney
	Outer	chest center	in th chest	diaphragm	spleen	abdomen	abdomen
The Classic of Difficult Issues (難經 nàn jīng)		heart small intestine	lung large intestine	liver gallbladder	spleen stomach	kidney bladder	pericardium triple burner
The *Pulse Canon* (脈經 mài jīng)		heart small intestine	lung large intestine	liver gallbladder	spleen stomach	kidney bladder	kidney bladder triple burner infant's door
Pulse Formula		heart small intestine	lung large intestine	liver gallbladder	spleen stomach	kidney	life gate
Thousand Golden Pieces Formulary		heart	lung	liver	spleen	kidney	kidney
Bin-Hu Sphygmology (瀕湖脈學 bīn hú mài xué)		heart chest	lung central	liver diaphragm	spleen lower	kidney umbilicus	life gate lower
Indispensable Medical Reading (醫宗必讀 yī zōng bì dú)		heart pericardial network	lung in the chest	liver spleen	spleen stomach	kidney bladder	kidney large intestine
Three-finger meditation		heart	lung	liver	spleen	kidney	life gate
Jing-Yue's Complete Compendium (景岳全書 jǐng yuè quán shū)		heart pericardial network	lung chest center	liver gallbladder	spleen stomach	kidney bladder large intestine	Kidney triple burner life gate small intestine
Pulse treatment		heart small intestine	lung large intestine	liver gallbladder	spleen stomach	kidney	life gate
Truth-Seeking Pulse Theory		heart chest center	lung in the chest	liver gallbladder	spleen stomach	kidney bladder small intestine	kidney triple burner life gate large intestine

tissue.

While carrying out a pulse examination, a physician uses three fingers on the positions of 'inch, bar, and cubit' to feel the vibration of the pulse on these positions carefully. This is the so-called pulse-taking in Chinese medicine.

As for the definition of the positions of 'inch, bar, and cubit', the most often used one is about the positions around the wrist where is located the radial artery. On the outer side of the wrist, there is a piece of protruding bone, the position of which is named as 'bar'. The position, which is closer to the side of palm and about one finger away from the palm, is named as 'inch'. The position, which is closer to the side of heart and about one finger away from the palm, is named as 'cubit'. This definition is for both right and left hands. Therefore, they are the mirror image to each other.

The sensors were respectively installed at the positions of 'inch, bar, and cubit' to measure the wave of pulse. The waveforms were almost identical. But the waveforms of the right hand were not totally the same as the ones of the left hand.

We can't help but ask : Is it a mistake, the three-finger knack that has been used for three thousand years ? Are they illusions, the debates about the five viscera and six bowels ?

We carried out again and again the pulse-taking on the positions of 'inch, bar, and cubit' with fingers and we also carried out the pulse-taking by using the pulse examination instruments and sensors. After having thought about this issue several times, we finally obtained some clues. They are not yet the answers but they can provide an idea as reference.

The inch opening pulse has nine tracts, that is, in modern language, the pulse waves at inch opening pulse are composed nine harmonic waves. In addition to the radial artery, we also obtained some pulse waves at other arteries. Interestingly, the pulse waves at inch opening pulse are very easy to be obtained. Perhaps, it's the main reason why the ancients chose the pulse waves at inch opening pulse.

Another feature of the pulse examination of inch opening (wrist pulse) is the composition of 0-11 harmonic waves and the vibration amplitude and is inversely proportional to the number of harmonics. From the 0^{th} harmonic, the vibration amplitude of the harmonic waves the more behind is smaller. Of course, it is the pulse obtained from normal persons. For the ill persons, the energy of the corresponding vibration amplitude of the ailing meridians or organs may become smaller or larger. For the seriously ill persons, the vibration amplitude may be smaller than the next or next two harmonic waves.

That the vibration amplitude becomes smaller and smaller with the increase of the number of harmonic waves allows us to know the relationship between the vibration amplitudes : heart (0) > liver (1) > kidney (2) > spleen (3) > lung (4) > stomach (5) > gallbladder (6) > bladder (7) > brain (8) > triple burner (三焦 sān jiāo) (9) > small intestine (10).

The number inside the brackets behind the name of organ is the number of harmonic waves of the corresponding pulse wave of each organ, for example, the heart presents the 0^{th} harmonic wave and the liver presents the 1st harmonic wave and so forth.

If a pulse wave is divided into three sections in respect of the timeline, the upper section mostly tends to present the 0^{th} and 4^{th} harmonic waves (because the lung and liver subdue each other, the 4^{th} harmonics wave could be more obviously observed in the upper section) (Wang 2002, 2011). The middle section presents the 1^{st}, 3^{rd} and 5^{th} harmonic waves and the lower section presents the 2^{nd} harmonics wave. Here we only take into consideration the 0^{th} to 5^{th} harmonic waves, i.e. the six largest harmonic waves obtained at the inch opening (wrist pulse).

If the pulse examination of the positions of 'inch, bar, and cubit' is not to obtain the absolute vibration amplitude of each position but the wave spread on the positions of 'inch, bar, and cubit' when it passes through the inch opening (wrist pulse), that is, the position of 'inch' corresponds to the upper section of pulse wave, the position of 'bar' corresponds to the middle section, and the position of 'cubit' corresponds to the lower section.

From this, the position of 'inch' corresponds to heart or lung. The position of 'bar' corresponds to spleen, stomach or liver and the position of 'cubit' corresponds to kidney. This is similar to the conclusion obtained by the ancients.

Floating, middle and sunken techniques:

The 'sunken pulse in floating pulse' is another myth in the pulse examination in Chinese medicine. Since ancient times, this technique has been attached importance to in the documents of pulse examination. However, when we used the sensors to measure the pulse wave on the radial artery, we found that pulse wave diagram obtained using more pressure is similar to the one using less pressure. Similarly, the results of the measurement on the positions of 'inch, bar, and cubit'

are similar to each other. In this case, how could we tell the difference with fingers?

Actually, precisely speaking, it's not correct to say the pulse wave obtained using more pressure is similar to the one using less pressure. Using too much pressure, the blood pressure wave would be blocked and the lower part of the pulse wave would disappear. Using too little pressure, the sensors would not be well attached to the artery and some details of pulse wave would be concealed. However, within a reasonable range, no more than diastolic blood pressure, no less than 20mmHg (a slight difference might occur depending on the response of sensors), the pulse waves measured by using the floating, middle and sunken techniques can't be distinguished to the naked eye.

We also proposed some modern ideas, as a reference, in respect of this traditional technique used in the pulse examination in Chinese medicine. The pulse-taking with fingers depends on the sensitive tactile sensation of fingers so the arms or palms are not suitable for it. No matter how sensitive the fingers are, the tactile sensation is after all a physiological response. In the studies of physiological feelings, there is a well-known theory called 'Weber-Fechner Law' found by Weber and Fechner. They discovered that in the transformation of the neural signals by a sense organ, there would be a transformation of logarithm.

If the size of signal is X and the reaction of nerve is Y, we can find Y= A logX and A is a constant. This relationship can be expressed in another form as $\Delta X / X = C$ and C is a constant, that is, if our sense organ detects an external signal with strength X, the strength that our sense organ could distinguish will be ΔX so that $\Delta X = CX$. In other words, where C=1 / 10, when a weight of 10 kg is measured by hand, the weight could be distinguished will be 1 kg; and, when a weight of 10 g is measured by hand, the weight could be distinguished will be 1 g.

After having understood this rule of physiological response, we investigated the possible intention of of the floating, middle and sunken techniques. If little pressure is used, with only 10 g, the vibration change of 1 g will be distinguished. If more pressure is used, with 100 g, the vibration change of 10 g will be distinguished. In the section about 'inch, bar, and cubit', we have mentioned the vibration amplitude of each harmonics wave A is as follows: A (C0) > A (C1) > A (C2) > A (C3) > A (C4) > A (C5) > A (C6) > A (C7) > A (C8) > A (C9) > A (C10). Among the pulse waves measures at the inch opening (wrist pulse), the harmonics wave with higher frequency has smaller vibration amplitude.

According to the relationship $\Delta X / X = C$, it can be inferred that it needs to obtain the vibration amplitude of the harmonics wave with lower frequency. That's because ΔX is larger, a larger X could be used in order to obtain a C with the same value. In the case with a larger X, the vibration change of the harmonics wave with higher frequency is ΔZ and $\Delta Z<\Delta X$; and, the physiological response obtained is D and $D<<C$. As a result, in the case with a larger pressure (sunken technique), the feeling perceived by the fingers in respect of the harmonics wave with higher frequency will be passivated.

Another physiological phenomenon to be taken into consideration is that five viscera belong to yin and their harmonics wave are as follows: C0 (heart), C1 (liver), C2 (kidney), C3 (spleen), C4 (lung). All of them are with low frequency. Slow ones are viscera and rapid ones are bowels. And, C5 (stomach), C6 (gallbladder), C7(bladder), C8 (large intestine), C9 (triple burner), C10 (small intestine). All of them are with high frequency.

The ones with low frequency will change slowly and the ones with high frequency will change rapidly. Where a little pressure (floating technique) is used, the changes of the five viscera in a short time will be smaller than the ones of the six bowels because the pulse of the five viscera changes slowly and the pulse of the six bowels changes rapidly. Therefore, if the floating technique is used to take pulse, the small and rapid changes could be easily perceived, that is, the resonance wave of the bowels.

From this, the ancients must have studied seriously. Indeed, if we carefully distinguish and deliberate the relationships between the different pressures used by fingers, the magnitude of the changes of pulse wave as well as the speed of the changes of vibration amplitude, we could distinguish the significant changes of vibration amplitude of some viscera or bowels.

Twenty-eight pulses and viscera-bowel pulses :

In the documents of pulse examination, the most emphasized ones are the twenty-eight pulses. And, in the prespective of practicability, the twenty-eight pulses may be easier to get started than the viscera-bowel pulses.

However, the twenty-eight pulses and the viscera-bowel pulses always coexist. One is easy to get started and to be learned and the other contains more information but is less easy to be obtained.

The twenty-eight pulses are signals of analog. Therefore, they are described as follows: string (弦

xián) -like pulse means the pulse is like a string; tight (紧 jǐn) pulse means the pulse presents an intensity; slippery (滑 huá) pulse means the pulse presents no resistance; rough (澀 sè) pulse means the pulse presents a large resistance and so forth. All are mainly described with words. According to the judgment by intuition, the twenty-eight pulses should be the collective change of pulse wave at the moment of the occurrence of a certain disease of the viscera or bowels. For example, in the sections about disease distinguishment and treatment argument in the nowaday textbook of Chinese medicine, the pulse examination has been always considered as a way to distinguish diseases. Among the exogenous diseases, for example, the externally contracted (外感 wài gǎn) wind-cold presents: the pulse is floating and tight (exterior repletion) or floating and moderate (exterior vacuity); the pulse is floating and tight but forceful (exterior repletion and internal heat, severe cold and heat); the pulse is floating and tight (exterior cold and internal rheum); the pulse is floating and rapid (at the beginning of warm disease); the pulse is floating and slightly surging (externally contracted wind-cold, cold depression transforming into heat).

All these are used to facilitate the distinguishment of the symptoms that may occur at the moment of an exogenous cold. But it can't facilitate the distinguishment of the affected area, including the channel, bowel and viscera.

That's because the floating pulse, rapid pulse, surging pulse and tight pulse are easier to be perceived. It's unlike the viscera-bowel pulses that need profound studies of the details of 'inch, bar, and cubit' or 'floating, middle and sunken techniques' and make people get lost easily on the contrary. This is also the result of the practical development of modern Chinese medicine in terms of diagnostics.

After having used the modern equipments and understood many details of the changes in pulse wave, how should we deal with or make use of these two similar but different and coexisting methods of pulse examination?

In modern sciences, Matrix A is often used to quantify the linear relationship between two things or states. For example, Y = AX.

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \begin{bmatrix} x_1 & x_2 & x_3 & x_4 \end{bmatrix}$$

It is used to indicate the relationship between Y (Y_1 Y_2 Y_3 Y_4) and X (X_1 X_2 X_3 X_4) is a matrix of order 4. It is used to indicate the linear relationship between four things or states. To indicate the linear relationship between n things or states, it needs to use a matrix of order n. In project economics, the famous Slutsky Matrix or Substitute Matrix could be used to quantify exchange value between the products or international trade. This Matrix is also used to quantify the situation of genetic changes. In physics, quantum mechanics also used this relationship to quantify energy levels of electrons (eigen--value) in an atom and its orbit (eigen-vector).

Moreover, in statistics, this matrix is the standard method used to quantify the correlations between two things and states.

In linear algebra, this matrix depends on the choice of the basis used to expand the states, and can have the most simple form through reductionism. Firstly, it needs to find the eigen-vectors of A. These eigen-vector must be orthogonal. When states are expressed in the eigen-space, Matrix A is then diagonalized.

Therefore, in finding the quantified relationships between some things or states, the most important step is to find the suitable orthogonal basis to express the states. Thus, if we want to find the relationships between the pulse examination and physical health, we must find the suitable orthogonal functions to expand the pulse wave.

After several years of research, we found the various harmonic waves with frequencies equal to the integer multiples of the heart rate are the simplest basis-functions; and the physical health can be examined quantitatively through the Fourier Transform of the pulse pressure P (t). We also derived a blood pressure wave propagation equation and found the generalized eigen-vectors of the equation (Lin Wang et al. 2008).

Furthermore, interestingly, after having carried out many experiments, we found that the eigen-frequencies of the axial position dependent part of the pressure wave equation are strongly correlated with the natural frequencies of the organs and the integer multiples of the heart rate. And, the harmonic Fourier components of the pulse wave could be used to quantify the health status of the correlated organs, meridians (Lin Wang et al. 2010).

In this process of research and development, the most surprising and grateful thing, is how our ancestors found the meridians and how they knew the resonance waves of the meridians were eigen-vectors.

So far, the advantages and disadvantages of the examination of viscera-bowel pulses and twenty-eight pulses are very clearly presented. The twenty-eight pulses are signals of analog. It's an accommodated method of measurement generated under the predicament of the pulse-taking only with fingers, which can't allow us to totally understand the physical health and can't be quantified.

Let's review the 'pulse examination of twelve meridians' and the 'three parts and nine indicators' proposed in the *Inner Canon*, they are the so-called the generalized examination of the whole body.

According to the *Inner Canon*, it is considered the distribution of the blood pressure wave is based on the 'twelve meridians' and standardized in accordance with the rules of the 'three parts'.

Although this diagnostic method was not adopted in the works by the later physicians, such as in the *Pulse Canon* by Wang Shu-he, and was not spread accordingly, this theory was unlike the one about 'inch, bar, and cubit' which generated many different opinions and endless arguments. Not only are there many different opinions about the corresponding viscera and bowels but also more arguments about the definition of the positions of 'inch, bar, and cubit'. If a phenomenon has been the subject of polemic for more than two thousand years, it must have some problems.

In contrast, that the pulse examination can allow us to know the physical health of the 'twelve meridians' has been the consensus for several thousand years. The arguments between many famous ancient physicians are only about how to choose the best points of measurement, how to define the points of measurement and how to analyze the signals obtained from these points of measurement.

During the period of our study of the pulse examination, although some famous biomechanics scholars questioned the pulse examination and some scholars engaged in the research of the signals of pulse examination also published a number of articles, none of them provided any significant discovery (Wang et al. 1977, 1978, 1980; Wei and Chou 1985).

Since the analyses of the signals of pulse examination only proved that the pulse examination with three fingers at the positions of 'inch, bar, and cubit' seemed difficult to provide the information about the physical health of the various organs or meridians, we started with the study of the distribution of blood to the 'twelve meridians' and their corresponding organs.

After having carried out the studies of the simulation of circulatory system by using balloons and water pipes and the studies of the arteries around the kidney and spleen of rats, we finally found the phenomenon of resonance in the blood circulatory system (Lin Wang et al., 1991, 2010). This theory provides not only a more precise method of measurement for the pulse examination but also a clear definition for the mysterious meridians, i.e. the core structure of Chinese medicine.

According to the generalized examination of the whole body proposed in the *Inner Canon*, we can infer the distribution of qi and blood of the human body is not completely laissez-faire. After the heart pushes the blood through the aortic valve, the blood pressure wave does not advance passively and the blood does not move ahead totally by itself. And, the theory about the moving ahead of blood by itself is the phenomenon of blood circulation introduced in the modern physiology. 'All arteries and organs are passive components like resistors'. Besides, owing to lack of a good understanding of the circulatory system, the prevalence of chronic diseases, such as hypertension, cardiovascular disease, cerebrovascular disease, diabetes, and diseases caused by the function degradation of lung or other organs has become a modern killer. And, for these diseases, there are mostly some conservative treatments for the symptoms and no fundamental rehabilitation therapies. Therefore, it needs to take medicine for more than a decade or even for decades.

(I) the whole body- pulse examination of twelve meridians:

Generalized examination:

After having understood more about the pulse examination by using modern scientific tools, we reviewed all the traditional pulse examinations mentioned previously. By using the theory of resonant blood circulation, it would be easier to understand the generalized examination of the whole body, i.e. the pulse examination of twelve meridians. Every channel or vessel is the highway for the transportation of a certain blood pressure wave's harmonics wave in the human body. The twelve meridians and vessels allow the twelve harmonics to move to the corresponding organs and the resonant organs with the same harmonics. As long as the blood is sent to the organ or acupuncture point, it only needs to make a tiny opening on the artery of such organ or acupuncture point, the blood will go into the surrounding tissues. It's like a tire full of air, a tiny opening on which can allow the air to go out. For

an artery full of blood, any tiny opening on which can allow the blood to flow out. From this phenomenon of resonant blood delivery, we could know that if the high-speed transportation highway is damaged, its ability to deliver the blood will become worse. Since the blood pressure wave sent to the organ or acupuncture point is damaged, the pulse wave of the organ or acupuncture point will disappear accordingly. That means the organ and meridians will get weak at the same time, that is, they will get sick. And vice versa, if the organ gets sick, the feature of resonance will diminish and then interfere in the blood delivery of the meridians; and, some changes in the vibration of the corresponding pulse wave will be generated, too. Therefore, through the vibration on the acupuncture point of the twelve meridians, we could know the situation of the blood delivery of the organs, meridians and then make the correct diagnosis.

(II) Three parts and nine indicators:

In the *Inner Canon*, we could find many records about the 'three parts and nine indicators'. That means the ancients attached particular importance to them but they were not handed down to the later generations. Cheng, Zhong-ling, a later physician, pointed out that 'there are tips for pulse examination, that is, only the three words: Stomach, Spirit, and Root'. It seems the essence of the 'three parts' is obtained.

1. Stomach: the *Inner Canon* indicates that 'stomach is the regular qi of a normal person'. Zhang Jing-Yue developed its meaning by mentioning that 'stomach qi is a person's yang qi. If yang qi gets weak, stomach qi will become weak. If yang qi gets vanquished, stomach qi will become scattered. It is the basic sign of life'.

2. Spirit: Zhang Jing-Yue mentioned that 'the one who is good at pulse examination will particularly observe the spirit, not the form. If one observes the form, he will not find the important clue because the form has thousands of shapes. If one observes the spirit, he could find the unique essence and unique reality'.

3. Root: the *Classic of Difficult Issues* mentions that 'if upper part has no pulse and lower part has pulse, it will be cumbersome but not harmful and could become better naturally. A person having cubit pulse is like a tree having roots. Although the branches and leaves are withered, the roots will grow naturally.' Therefore, whether a person has the root pulse is an important sign of the absence, exuberance and debilitation of qi in the kidney. "A physician must know" 'two cubit is the position of kidney, six pulses of sunken indicators are related to kidney'. Actually, this viewpoint is directly connected to the three parts. Stomach is to diagnose the middle part (man), Spirit is to diagnose the upper part (heaven) and Root is to diagnose the lower part (earth).

When we were measuring the three acupuncture points at the upper part, we found the 6^{th} harmonics was larger than great abyss (the inch opening (wrist pulse)) by dozens of percentage points (%). It shows that the upper part of the human body presents common resonance frequency, that is, the 6^{th} harmonics. By using the same method, we found that the 2^{nd} harmonic was the common resonance frequency after having compared the three acupuncture points at the lower part to the inch opening (wrist pulse). Similarly, after having compared the three acupuncture points at the middle part to the ones at the upper or lower parts, we found the 4^{th} harmonic was larger by dozens of percentage points (%). It shows that the 4^{th} harmonic was the common resonance frequency at the middle part (Wang et al. 1989).

From this experiment, we could know that the three parts in the 'three parts and nine indicators' have a special physiological significance. They should present the resonance frequency of the blood vessels of the head (the 6^{th} harmonic), the resonance frequency of the blood vessels of the hand (the 4^{th} harmonic), and the resonance frequency of the blood vessels of the foot (the 2^{nd} harmonic). If we measure the distance from the heart to the head, from the heart to the hand, and from the heart to the foot, we also find that the proportion is 1:2:3. Therefore, it is a reasonable inference that the three parts present the resonance frequency of the measured blood vessels. All these were proven by experiments. And, the 'twelve meridians' all have their respective corresponding harmonics; for the special applications of this theory in respect of diagnosis and treatment, please see (Wang 2002, 2011).

Pulse Examination, Disease, and Prescription

In the *Inner Canon* and Zhang Zhong-jing's works, the pulse examination and the diseases are connected through carefully deliberate and distinguish the onset and process of an illness and the pathology. In the *Pulse Canon* by Wang Shu-he, in order to highlight the status of the pulse examination, the correspondences between the pulses and the diseases were dealt with directly. A single corresponding relationship between a pulse and a disease was built. And, even for the prescriptions, many single corresponding relationships were built. For example, if the pulse over bar is slightly floating

and accumulated heat is in the stomach, there should be vomiting of roundworm and heart forgetfulness; if the pulse over bar is tight and slippery, there should be roundworm; if the cubit pulse is sunken and slippery, there should be inch white worm; if the pulse is felt at eight inch and goes to fish border, there should be enuresis. Moreover, in the 3rd text about the manifestations of disease and the treatments of the normal three bars, the single corresponding relationships between a pulse and a treatment prescription were built. As to the so-called roundworm or white worm or enuresis, if we use the method of modern scientific proof to prove these is no roundworm or white worm or enuresis, could we prove that the *Pulse Canon* is incorrect?

The *Pulse Canon* almost used the method of exhaustion to include all kinds of possibilities to build the one-to-one correspondence between the pulses at the parts of 'inch, bar, and cubit' and twenty-four pulses and all kinds of diseases. It seems that we could never see so many kinds of changes and so many kinds of diseases during ninety years for three lives. It is obvious that the single corresponding relationships built in the *Pulse Canon* were a game of permutations and combinations rather a collection of written records of clinical experiences.

In our point of view, this book is the best error sample of Chinese culture. The ancient sages found an analogy relation and then many interpretations were generated to express the analogy relation between two systems. Naturally, it's impossible to obtain a complete deduction of the distribution of blood of the twelve meridians and network vessels by using 'yin and yang' and 'five phases'. Only 70% to 80% of correctness could be achieved.

And, the later generations didn't carry out any verification but infinitely expanded this analogy relation instead. There are inevitably many unbelievable mistakes. As to the herbal foundation and formula study, because they were not confused by the documents of the pulse examination, they became the fields with more development in Chinese medicine since the Qin and Han Dynasties. Because there were always some experiments on human body and some plagues, the physicians could not help but face the reality and seriously face the consequences and correct the errors with a practical and realistic attitude. Therefore, after the Han and Jin Dynasties, there were some Chinese medicine and prescription masters, such as Sun Si-miao (孫思邈 sūn sī miǎo) and Li Shi-zhen (李時珍 lǐ shí zhēn). On the contrary, both the basic Chinese medicine theory according to twelve meridians and network vessels and the Chinese medicine diagnosis according to the pulse examination become a chaos and go back to the dawn of the beginning of the world. However, the examination of the tongue has made substantial progress in Chinese medicine because it is easy to perform and verify.

The Future of the Pulse Examination

The development of a science should be continuously verified. The great British philosopher Francis Bacon was the advocate of verifications and he was also the founder of modern experimental science. He advocated to carry out verifications by using newly invented tools. Although he also emphasized the method of induction as a means of advancing sciences, he always emphasized the method of verification in the induction process. Especially, he suggested that people should correct the bad habits in a variety of sciences and inexplicable worship of idols that he considered as the biggest obstacles to the advances in technology.

He mentioned four kinds of worship of idols:

1) idols of the Tribe:

The instinct of human cognition might cause some distortions of things and these distortions become part of the common knowledge among human beings. That the misuse of the concept of 'yin and yang' and 'five phases' in Chinese culture generated a culture like the Yihetuan Movement (also known as Boxer Uprising) is a terrible example.

2) idols of cave:

It refers to any theory that is developed according to an individual's personal limited experiences or personal belief or imagination. For example, some religious figures or Qigong masters always consider they are particularly blessed and have extraordinary supernatural or magic powers.

3) idols of market place:

It refers to the power by word of mouth or by word of the public to make the wrong become the right. That the large-scale rallies during the election campaigns in Taiwan that cause the opposition between the blue and green electors is the best example of the use of idols of market place by the politicians.

4) idols of theater:

The world is actually a theater. The past experiences and all kinds of knowledge were accumulated in the

textbooks, books, films and novels. If the knowledge were not proven, it may be a wrong display or performance. We must be prudent. And the singers and movie stars created in our time are exactly the typical idols of theater.

If we want to maintain these worships of idols, they must be proven right and they will be worthy of being worshiped.

Before the era of Bacon, there was no obvious difference of economy and civilization between the East and West. The economy and civilization of the West was mainly located in Italy in Europe. And the economy and civilization of the East was in China. Owing to the expansion of the influence of Bacon, the center of the civilization of the West was moved to the United Kingdom and then the Industrial Revolution was generated and the British Empire was built. The development of the economy and civilization of the West started to get separated from the religions but achieved magnificent results in the Industrial Revolution by bringing the fruits of science and technology to daily life and daily productions.

Bacon's philosophy facilitated the leaps and bounds in the development of the economy and civilization of the West. Can it provide something for us to learn?

The present article makes use of it sincerely to submit some suggestions here for the future development of the pulse examination.

It is suggested to use objective tests (tools) and inductive method as the rules to verify all past or new theories of the pulse examination. It is suggested to develop new analysis about the diagnoses of all kinds of physical conditions and the treatments of all kinds of diseases. It is suggested not to follow the rules of interpretations of the pulse examination (as used in the *Pulse Canon*) , which only used the method of exhaustion to include all kinds of possibilities without any verification or inductive method.

After having carried out a large number of experiments, we proposed a tool for the pulse examination as the basis of further verifications and also as the beginning of distillation. And, in respect of the basic Chinese medicine theory, we also integrated the definition of twelve meridians and network vessels and the principles of the pulse examination.

We only proposed a pulse examination instrument as a tool that was produced according to the physiological basic data about the twelve meridians and network vessels after the verifications and inductions. This objective tool, without depending on the sense of touch of fingers, can be provided as the beginning point of the future development of the pulse examination. Because it is entirely mechanical operation, the data could be easily represented. Because the operation is simple, the verification becomes easy. Because it doesn't depend on the sense of touch, there is no subject judgment and no need to conduct a long-term training or learning, it can become very popular easily. Because the same phenomena also happen to animals, a great part of the verifications could be carried out through animal experiments to improve the efficiency of verification.

It is suggested to investigate the function of a certain remedy according to the principles of the pulse examination in order to develop the new prescriptions to cure various prevalent modern diseases, especially the metabolic chronic diseases.

It is suggested to make use of the principles of the pulse examination to verify the active ingredients of a certain remedy through animal experiments. It is suggested to make use of the principles of the pulse examination to investigate, through animal experiments, the pharmacology of Chinese medicine that is helpful for the improvement of blood circulation of a certain organ. These are a number of specific directions provided as an initial step to start new discussions, even in new directions.

Let's jointly participate in and look forward to a new health revolution, as the Industrial Revolution, to launch another brand-new phase of human civilization.

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Supplement
脈診的過去、現在與未來

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摘要

脈診爲中醫之特有診斷手法，在中醫之歷史中對脈診之記述充滿了驚奇與神話。經過了三十年的血液流體力學研究，同時在臨床應用上也做了一些探索。

本文僅就三十年來之心得，將過去脈診發展過程中之轉折、功過做一些分解。對古人之心得也嘗試以現代的知識及語言加以剖析。在共振式血液循環現象發現之後，中醫將可能站在力學大師牛頓先生的肩膀上，引領現代醫學的發展。

希望這一個經由時域與位置之特徵向量經絡而發展之脈診工具，可以爲中醫帶來活水。以量化之研究穿越過去僅用類比邏輯定性之困境，以發揚光大，以帶來新的健康革命。

前言

脈診是中醫之象徵，也是中醫之特色。有關中醫的著作，總把三指把脈當成重要圖面，而一講到中醫，人們心中想到的也大多是三指把脈的圖象。在中醫四診之中，望聞問都在現代醫學中有了更精進的發展，由尤其是望診，在現代醫學影像：如X-CT，MRI，PET，超音波等技術之日新月異，如內視鏡：胃鏡，大腸鏡，小腸鏡，顯微鏡設備等之精益求精情況下，使望診的領域擴大成眼見爲憑的醫學。而聞診也由血液檢查，尿液檢查，等方法的突飛猛進，加上方便又便宜，已使之成爲現代一切診斷的基本資料。

在這樣的環境下，我們還來討論脈診，一方面因它是中醫唯一沒有被現代醫學了解並開發的特有診斷方法。另方面也是要深入了解中醫的一個寶貴大門。

脈診的過去

脈診史上，最早有文字記載的，始見於左傳昭公元年，記載秦公派秦和診治晉侯之病，秦和參以色脈詳論其病。在周禮注中就進一步說明“脈之大候要在陽明寸口，能專是者其爲秦和乎”。後漢書中也有涪翁善于切脈，並著脈法之記載。也記載有郭玉擅有“方診穴微之技，陰陽不測之術”。

其他由考古學發掘出之文獻，如“流沙墮簡”，“武威漢代簡”，“五十二病方”等，皆是較內經更早之著作，但是作者已不可考。比較有系統性記載的是扁鵲脈法，扁鵲又名秦越人，“史記扁鵲倉公列傳”記載“至今天下言脈者，由扁鵲也”。淮南子也指出，其隨病而調藥，擾息脈血而知病生。

扁鵲的時代與內經有些重疊，有些著作與內經相似或完全相同，但不同的也有一部份，如十怪脈等，而扁鵲與內經最大不同是內經有十二經診法，三部九候，而扁鵲脈法全部用獨取寸口。

扁鵲特別重視一天之中，一年之中脈的變化。提出了陰陽脈法。注重三陰三陽脈之時空變化規律。倉公，淳于意爲扁鵲之傳人，也是主張獨取寸口。使用之脈象已有浮沉弦瀛緊清數堅實長大少弱平鼓靜躁散代等脈，加上番陰，番陽，併明等二十二種之多。其對熱病之見解，也被後世多所引用，例如併陽脈認爲是陰陽交，爲最危急之兩感症：“汗出輒復熱，而脈躁疾不爲汗衰，狂言不能食。”。併陰脈“脈順清而愈”。爲內經素問評熱病論，或仲景傷寒論“傷寒一日，太陽受之，脈若靜者爲不傳”等經典所引用。

倉公雖認爲四診皆不可缺，但對脈診情有獨鍾，“病名多相類，不可知，故古聖人爲之脈法。以起度量，立規矩。縣權衡，案繩墨，調陰陽，別人之脈，各名之與天地相應，參合與人故乃別百病以異之”。

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他不僅引用許多上古醫學文獻如脈法、診脈法、診法、奇咳等文獻，並有宋邑、杜信、唐安等傳人，對脈學之傳承有很大貢獻。

由文獻“中藏經”，“華陀神醫密傳”，“內照法”等可知，華佗脈診法主要傳承自扁鵲，其診法也是獨取寸口法。首度分別寸關尺與各臟腑之間的對應關係，如左寸屬心，小腸，左關屬肝膽，左尺屬腎，右寸屬肺，右關屬脾。而其他部份則未有文獻可供參考。

自倉公獨取寸口，但不分寸關尺，其用指或二，或三齊按。而按法也僅有浮沉。至華佗，才提出三指分三部，可三指同按，也可分別單指使用。已將臟腑脈法發展成熟，而一些未表明之部份臟腑，很可能是文獻遺失。華佗也提出陰陽脈，表里脈，寒熱脈，虛實脈等八綱脈法，與臟腑脈法並列。

內經之脈法源出“醫經”一派，而內經爲“醫經”派的第一部文字記載並流傳至今之經典，也是最重要的一部醫經經典。不僅綜合了古代的脈法，如扁鵲，倉公，華佗等人之脈學理論，且承先啓後，至今仍爲中醫理論之基礎骨幹。

內經之內容，收藏並整理了戰國、秦漢時間的相關醫學知識。主軸由陰陽，五行，臟腑，經絡等一體貫穿，成爲至今無人能超越的唯一經典。但對脈學論述上，因爲其原則，方法，脈象及至主病等等都沒有一致的說法，改以“兼容並蓄”的方式處理。

在內經素問中之“三部九候論”實爲十二經診法之演化而來。內經之脈學理論以陰陽爲基本，認爲經絡即血脈。認爲血液是經由十二經（非由現代所稱之血管）來傳遞，故脈診就是檢查診斷血液在人體分佈之情況。如正常爲平脈，不正常爲病脈，以內經的觀點已明確指示脈診是診察經絡的。診經絡可以直接在經絡上的脈動點上診察，也可借由寸口一處之脈動，來分別十二經，或三部九候。這也是後世脈診發展所依據。而王叔和的“脈經”有寸口分九道，以及寸關尺之分屬各經絡之理論，成爲後世脈學之主流，但在現代脈學大師趙恩儉先生的眼中，“其中遍診的思想和方法內容沒有得到繼承與發展是一個重大問題，也是後世脈法得不到巨大發展的關鍵所在，否則全身性的查體必然會得到很大的發展，以時間之長與實踐之多，全身性的“切”診早就應當從各方面完備起來，而不會兩千年來，中醫在檢查病人時，接觸到人體的點不過是摸摸橈動脈而已”(Chao, 1988)。

總結

在過去的脈診文獻中，內經已經集其大成，後世之醫家只是在內經的框架中截長取短。有些地方有些進展，又在其他地方迷失了方向。這個現象在中華文化之發展中，屢見不鮮。直到現代還是有人像新朝（漢）王莽一樣，主張一切回歸古代經典，文化。對中醫也同樣主張，一切回歸內經之醫理及張仲景等之經方。

經過多方思索中華文化之特質，得到一個很有趣的觀點。

中華文化的邏輯系統，一直是類比的。不論陰陽五行，易經六十四卦，脈診二十八脈，都是以類比的方式做定性的敘述，多以文字來描述。不但缺乏操作型的定義，更沒有數量化的觀念。當時之古人，可能是扁鵲或更早的一位天才，發現了可以陰陽及五行，金、木、水、火、土來類比身體時，同時又有另一位天才，發現金、木、水、火、土，可以用來類比天文，四季。這可是驚天動地的大發現。

中華文化主張天人合一，內經認爲人是有天地人的小宇宙，都是這個文化的代表作。

我們在思索這個類比邏輯，亦即以陰陽五行來描述天下萬物時，得到一個想法。

在世上有記載的事物，大多是有週期性的。因爲不是週期性的事務，一閃而過，我們沒有機會重覆觀察。更沒有機會做詳細的記載，也就不易存在於我們的歷史及文化中。

太陽落下，升起，四季更替，星象之週而復始、、、都是世界各地古老文明所共同了解的。埃及人崇拜太陽，馬雅人了解星象，可算出千百年之後的日蝕，月蝕，都是明顯的例子。而中國，馬雅，埃及都有萬年曆，這是多麼偉大的成就。

但在中華古老文化中，我們創造了陰陽五行來描述天下事物間之關係。這個五元文化表面看起來與希臘的四元或希伯來的六元沒有甚麼不同，但更妙的是這五元文化所引伸出來之相生相剋，可用週期性信號組成的諧波來了解。（Wang 2002，Wang et al. 1989）

這個五行相生相剋文化可以諧波間的相生相剋關係解釋大約七成至八成。

因爲有七、八成的正確性，這是對所有週期性事務都可能使用的，所以在內經中用來解釋生理學中之循環現象，也就是脈波的特性。因爲心臟一直重覆的跳動著，其所產生的脈波，以五行相生相剋來敘述，也就有了七、八成的正確性。這在生理學完全沒有了解的年代是何等偉大的大事。

所以中醫由類比的邏輯所引伸出的各種理論，不必經由解剖學，生理學，也不必了解細胞學，不必了解各器官的功用，也不必知道有內分泌，或是神經，甚至血管的分佈，我們的先知們就能一下子跳到辨證及治療。這就是類比邏輯的威力！這也就是古聖先賢的偉大智慧！！

但這個類比關係不僅不是全面的精確，而且終

究只是個類比的相似。類比邏輯的最大缺點就是無法數量化。因爲無法做數量化，就無法做精確的驗證。古聖先賢首度在二、三千年或更早以前領悟到這個偉大的類比關係之後，後人如果仍侷限在這個類比關係中，只會因爲理解的侷限，或顧此失彼的想要擴大適用範圍；但終究因沒能從事量化的驗證工作，於是正道、邪道、眞理與謊言一直併存在秦漢以來的文獻之中。

脈診究竟在診察甚麼？

1. 全身十二經絡：

A. 十二經診法：即各取手足三陰三陽十二經脈中一處浮露或較爲浮露的具有代表意義或便於診察的動脈，以診察動脈（脈氣）的方法。其具體部位爲：

太淵： 肺，寸口。
陽溪： 大腸，手合谷上。
後陽： 胃，足跗。
後門： 脾，腹下前後溝縫。
陽郄： 心，神門內。
天窗： 小腸，喉旁。
委中： 膀胱，胭宛。
太溪： 腎，踝里旁穴。
勞宮： 色絡，掌心。
和髎： 三焦，耳與目之間。
懸鐘： 膽，外廉踝之上。
太後： 肝，足大趾上跗。

在脈診之草創時期，是在全身十二經絡上做診斷。

在中醫之發展史中，最爲神秘的是十二經絡。在最早有文字記載的馬王堆出土文獻中，就已有心經以外之十一經。到了內經時就有了十二經的全部。而不像脈診或藥方，可由文獻追蹤其發展過程。

遍診全身十二經，是比較容易理解的，脈診的目的就是了解氣血（脈動）在全身十二經絡中之分配情形。所以獨大者病，獨小者病。一定要分佈均勻，才是平脈，也就是正常的脈。由內經的這個主張來看，脈診就診斷血液在經絡內之分配情形，而病可以產生脈動在十二經上的不平衡的分配。所以脈診就是診斷經絡的健康。而十二經是陰，也就是血液分佈的幾何結構，而脈是陽，是血液在灌輸十二經者產生之振動。了解了脈診的原理，就能了解經絡，而在經絡的研究上有了突破，就能了解脈診。二者是一體的兩面。

2. 三部九候：

B. 三部九候診法　此法見“素問、三部九候論”，其具體部位爲：

上部天：兩頰之動脈，在額兩旁足少陽經。
上部地：兩頰之動脈，鼻兩旁近於巨髎陽明經。
上部人：耳前之動脈，耳前陷者中手少陽經。
中部天：手太陰，寸口。
中部地：手陽明，合谷。
中部人：手少陰，神門。
下部天：足厥陰，毛際外羊關下一寸半陷中，五里之分，臥而取之，女子取太衝在足大指本節後二寸陷中。
下部地：足少陰，在足內踝骨上陷中，太溪。
下部人：足太陰，在魚腹上趨筋間，直五里下箕門之分，寬足單衣沉取乃得之，候胃氣當取足跗之上後陽之分。

三部九候在內經中佔有很大的篇幅。許多現代醫家都認爲這只是十二經診法的相同手法，也是遍診法，沒有多少特定意義。

3. 寸關尺：

在橈動脈上把脈一直是中醫的象徵，由扁鵲起就由寸口把脈。早期的定義在華佗時已對臟腑有了明確的區分。例如左寸屬心，小腸，左關屬肝，膽，左尺屬腎，右寸屬肺，右關屬脾。胃脈則屬關上，但未指關上爲何位置。但到了後世就稍有分歧，但大體不失其宗，總以華佗之分類爲主軸。有關左、右寸關尺與臟腑的關係，將歷代比較重要文件整理如表一。

在脈診工具建構完成之後，從1988年至1990年間，我們做了許多寸關尺的分部測量。當傳感應器分別放在寸關尺，或寸之更前方一點些，或尺之更後方一些。在左手所得到的脈象，都在測量的誤差範圍之內，換言之，就是幾乎相同。而右手的寸關尺也有相同的結果，就是幾乎相同。

這個結果有些出乎意料。但由血液流體力學的角度來看，似乎又是必然的，因血液在動脈中由近心端往遠心端流，不論是血液壓力波，或血液之流體波，都是連續的，又怎能在不到5公分的血管長度中產生重大的變化呢？除非這一段的動脈血管，或周遭組織，在寸關尺的位置有重大結構變化。爲了拯救中醫，有人提出雜型學理論，認爲這一小段血管與周遭之組織，可以反映身體其他部位或器官的結構。但這一段血管或周遭之組織並沒有發現任何特異的改變，不論是平人或是病人。

脈診時，以三指分別放在寸、關、尺的位置，而用心去感覺這三個位置脈波的振動。這就是中醫所謂的把脈。

至於如何定義寸、關、尺的位置，則最常用的是在橈動脈經過手腕的部位，其外側有一塊骨頭突起，以此骨頭的位置定爲關，而較靠近手掌約一指位置爲寸，而靠近心臟的一指位置定義爲尺。左右手都依此定義，所以互爲鏡中之像。

表一、左、右寸關尺與臟腑的關係

著作		寸		關		尺	
		左	右	左	右	左	右
內經	內	心	肺	肝	胃	腎	腎
	外	膻中	胸中	膈	脾	腹	腹
難經		心 小腸	肺 大腸	肝 膽	脾 胃	腎 膀胱	心包 三焦
脈經		心 小腸	肺 大腸	肝 膽	脾 胃	腎 膀胱	腎 膀胱 三焦 子户
脈訣		心 小腸	肺 大腸	肝 膽	脾 胃	腎	命門
千金方		心	肺	肝	脾	腎	腎
瀕湖脈學		心 胸	肺 中	肝 膈	脾 下	腎 臍	命門 下
醫宗必讀		心 心包絡	肺 胸中	肝 脾	脾 胃	腎 膀胱	腎 大腸
三指禪		心	肺	肝	脾	腎	命門
景岳全書		心 心包絡	肺 膻中	肝 膽	脾 胃	腎 膀胱 大腸	腎 三焦 命門 小腸
脈如		心 小腸	肺 大腸	肝 膽	脾 胃	腎	命門
脈理求眞		心 中	肺 胸中	肝 膽	脾 胃	腎 膀胱 小腸	腎 三焦 命門 大腸

我們以傳感器分別在寸、關、尺的位置測量脈波，則所得波形幾乎完全相同，但左右手則不盡相同。

我們不禁要問：過去使用了三千年的三指訣難道錯了嗎？那些五臟六腑分屬的爭論，都是鏡花雪水月？

我們一再以手指在寸關尺把脈，也同時以脈診儀，用傳感器來把脈，幾經思量，終於得到一些線索。這不能說是答案，只是提供一條思路，供大家參考。

如果說寸口脈分九道，以現代的語言來說，就是寸口脈波中有九種諧波。我們除橈動脈，也在其它動脈取得脈波。有趣的是寸口脈波非常好取，這恐怕是古人選用寸口脈波的一個重要因素。

而寸口脈診另有特色，就是由0到11個諧波，其振幅與諧波數成相反走勢。由第0諧波起，愈後面的諧波，其振幅愈小。當然這是平人之脈波，如果生病了，則生病的經絡或器官，其對應的諧波的能量就可能變小，如病沉重，則甚至小於下一個或二個諧波的振幅。

這個振幅隨著諧波數之增加而愈來愈小的現象，讓我們知道振幅之間的關係，心（0）＞肝（1）＞腎（2）＞脾（3）＞肺（4）＞胃（5）＞膽（6）＞膀胱（7）＞大腦（8）＞三焦（9）＞小腸（10）。

臟腑後面括號中之數字爲該臟腑所對應的脈波中之諧波數，如心爲第0諧波，肝爲第1諧波，以此類推。

如果把一個脈波在時間軸上分爲三段，則上段最容易表現的是第0諧波、第4諧波(因肺與肝之相剋，使得第四諧波在上段之手感加強)(Wang 2002, 2011)，而中段爲第1諧波、第3諧波、第5諧波，末段爲第2諧波。我們在此只考慮0 – 5諧波，也就是在寸口測量時較大的六個諧波。

如果寸、關、尺所要量測的不是每個位置的絕對脈幅，而是當脈波經過寸口時，將這個波展開在寸關尺的位置，寸的部位對應脈波的上段，關的位置對應中段，而尺的位置對應末段。

由此看來，寸對應心或肺，而關對應脾、胃或肝，而尺對應腎，也就與古人所得的結論有些相似了。

浮中沉：

浮中沉是中醫脈診方法中的另一個迷思。自古以來，在脈診的文獻之中，一再強調此手法之重要。可是當我們以轉感器在橈動脈上測量脈波時，卻發現不論壓重些，或壓輕些，所量得脈波圖都是相似的，這點與在寸、關、尺三部份分別測量脈波，其結果是一樣的，都是相似的，以手指又怎能分別呢？

其實也不能說不論多重，脈波都是相似的。如果太重了，血液壓力波會受阻，脈波中下面部份會不見了。如果太輕了，則轉感器與動脈接觸不好，一些脈波的細節將被掩蓋。但在合理的範圍內，不要大於心舒壓，不要小於20mmHg壓力（視轉感器之反應而略有出入），則以浮、中、沉手法所測得脈波，無法以肉眼分辨。

我們也試著對這個中醫脈診的傳統手法，提出一些現代的想法，作爲大家參考。

以手指診脈，依靠的是手指靈敏的觸覺，所以不用手臂，也不用手掌。

不論手指有多靈敏，終究是觸覺的生理反應，在生理的感覺研究中，有個非常著的定理，叫做Weber-Fechuer Law。由Weber與 Fechuer 所發現。Weber與Fechuer 發現感覺器官轉換爲神經信號時，會經過一次對數之轉換。

如果信號之大小爲X，而神經之反應爲Y，則Y= A logX，A爲常數。這關係可以另一個形式來表達，ΔX / X= C，C爲常數。就是外來信號的強度爲 X，由我們感覺器官來偵測，我們感覺器官能分辨的強度是 ΔX，而ΔX= CX，換言之，如果 C=1 / 10，則以手秤10公斤的重量，能夠分辨的重量爲1公斤。如果以手秤10公克的重量，手能分辨的重量是1公克。

了解了這個生理反應的規則，我們再來探討浮、中、沉的可能用意。

如果用力少，爲10公克，則可以分辨1公克的振動變化，如果用力大，100公克則可以分辨10公克的振動變化。我們在寸、關、尺一節中已介紹過，各諧波振幅 A 之大小爲 A（C0）＞A（C1）＞A（C2）＞A（C3）＞A（C4）＞A（C5）＞A（C6）＞A（C7）＞A（C8）＞A（C9）＞A（C10）。在寸口處測量之脈波，頻率愈高之諧波其振幅愈小。

由 $\Delta X / X = C$ 的關係，可推知，要測得低頻之諧波、振幅，因爲 ΔX較大，爲得到相同的 C，可用較大的 X。而在較大 X之狀況下，其他高頻之諧波之振幅變化 ΔZ，$\Delta Z < \Delta X$，所得之生理反應 D 也就 $D << C$。如此一來，在較用力（沉）之狀況下，對高頻諧波手指所產生的感覺，就被鈍化了。

還有一個生理現象也要一併考慮，就是五臟屬陰，諧波由 C0（心），C1（肝），C2（腎），C3（脾），C4（肺），都是低頻的，遲者臟也。速者腑也，C5（胃），C6（膽），C7（膀胱），C8（大腸），C9（三焦），C10（小腸），都是高頻的。

低頻的變化慢，高頻的變化快。如果在輕取時（浮），五臟之脈因爲變化的慢，在短時間內之變化，反較快速變化之六腑之脈爲小。故在浮取時，容易感覺小而快速之變，也就是腑的共振波。

由此看來，古人還是研究過的。在手指用力下壓之大小，與脈波變化之大小，及振幅變化之快慢之間，仔細拿捏，用心推敲，確實有可能可以分辨某些臟，或腑的振幅發生重大改變的情況。

二十八脈與臟腑脈：

在脈診的文獻中，強調最多的是二十八脈，就實用性而言，這二十八脈可能比臟腑脈容易上手。

可是二十八脈與臟腑脈一直併存著，一個是因爲容易上手，容易學習，另一個是資訊的含量較豐富，但是不易取得。

二十八脈是個類比的信號，所以描寫的例如弦：表示像弓弦，緊：表示有力度，滑：表示沒有阻力，澀：表示阻力大。……。都是文字的敘述爲主。由直覺的判斷，二十八脈應是，臟腑在對應一個特定疾病時，所發生的一個集合性的脈波變化，例如近代的中醫教本總是在辨證論治中，把脈診作爲辨證的一個手段。又例如以外感疾病而言，外感風寒：脈浮緊（表實），或浮緩（表虛），脈浮緊有力（表實裏熱，寒熱俱重），脈浮緊（表寒內飲），脈浮數（溫病初起），脈浮微洪（外感風寒，寒郁化熱）。

這些都是用來協助辨別外感之風寒，所可能發生的症狀。但是並不能協助分辨傳到那一經，那一腑，或那一臟。

因爲浮、散、洪、緊等都是比較容易體會的。不必像臟腑脈需要努力的在寸、關、尺或浮、中、沉等細節上下功夫，反而迷失了方向。這也是近代中醫在診斷學上，向務實的方向發展的結果。

但在有了現代化的機器，也了解了許多脈波變化細節後，又該怎麼來看待這二種又相似，又不同，但同時存在的脈診方法呢？

在現代科學中，描寫兩個事物中線性相關係，常用矩陣 A，如 $Y = AX$

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \begin{bmatrix} x_1 & x_2 & x_3 & x_4 \end{bmatrix}$$

表示 Y（Y_1 Y_2 Y_3 Y_4）與 X（X_1 X_2 X_3 X_4）間之關係爲四階之矩陣，用來表示四種事物或狀態之間的線性關係，如爲n種事物或狀態，則須n階之矩陣。計量經濟學中著名的Slutsky Matrix，或Substitute Matrix，可以量化產品間之交換價值或是國際貿易等。此Matrix也被用來量化基因變化的情形。物理學中量子力學也用此關係來量化一個原子中的電子能階（特徵值），及其軌道（特徵向量）。

這個矩陣法更是統計學中，用來找尋二個線性相關事物中相關性的標準做法。

這個矩陣在線性代數中有些標準的解法，也就是簡化法。要找到A的特徵向量（eigen-vector）。此特徵向量必須是垂直正交的（orthogonal）。在此特徵空間中（eigen-space），則矩陣A，可以經由對角化，而大大簡化。

所以在找尋事物或狀態間的計量化關係，最重要的是要找到合適的正交基底函數來表示狀態。因此，如果我們要找出脈診與身體健康間的關係，我們必須先找到展開脈波的合適的正交基底函數。

我們經過多年研究，發現頻率等於心率整數倍數的簡諧波是展開脈波最簡單的正交基底函數。發現脈波函數 P（t）在經過了佛氏轉換（Fourier Transform）之後，所得之各個諧波大小即可將身體健康做一個簡單之計量描述。

我們也導出了血液壓力波的前進方程式，並將此方程式有關位置特徵向量或共振波找出來（Lin Wang et al. 2008）。而有趣的是，經過我們許多實驗證明，這些特徵向量與經絡的分佈，有很強的相關性。其特徵值與器官的天然頻各個特徵向量的振幅，可以用來量化各器官及經絡的健康狀態（Lin Wang et al. 2010）。

在這個研發的過程中，令我們最驚奇，也最感謝的是我們的祖先，他們是怎麼知道經絡的？又怎知經絡是特徵向量。

行筆至此，臟腑脈診與二十八脈的優劣，大家一定了然於心。二十八脈是類比信號，是在指下難

明的困境下的妥協後的量測方法，是無法對健康有全面的理解，也無法量化的。

讓我們再回顧一下內經所提出的十二經診法與三部九候診法，就是所謂全身遍診法。

由此可以推論，血液壓力波在身體的分佈是根據十二經絡，或三部的規則來規範的。

這個診法雖然沒有被後世醫家如王叔和之脈經等所採用，因而沒有流傳，但這個理論並不像寸關尺一樣，有許多不同的看法而爭論不休。不僅寸關尺所對應的臟腑有許多不同的看法，而爭論更多的是寸關尺如何定位，如何定義。一個現象如果論戰了二千多年仍不能定義，就表示一定有問題。

反觀由脈診可以診知十二經絡的健康狀況，卻是數千年來從未改變的共識。歷代以來多位著名醫家所爭論的，只是如何選擇最佳測量點，如何定義測量點，及如何分析測量點所測得的信號。

我們在進入脈診研究的時間，正是一些生物力學的大師們對脈診提出質疑，而從事脈診信號分析的學者，雖然也發表了一些文章，但都沒有重要的發現（Wang et al. 1977, 1978, 1980; Wei and Chou 1985）。

既然直接從事信號分析的方法只是証明了脈診以三指在寸關尺測量，似乎是不可能得到各臟腑或經絡的健康信息，我們就由血液分配至十二經絡及其對應器官的方向入手。

經過了以氣球、水管的模擬循環系統的研究及老鼠的夾腎、脾動脈等的研究。終於發現了血液循環系統中之共振現象（Lin Wang et al., 1991, 2010）。這個理論不僅爲脈診找到更精確的測量方法，也爲神秘的經絡 _ 中醫的核心架構，找到了明確的定義。

由內經之全身診法，就可以推論內經認爲身體中氣血的分配，不是完全放任的；心臟將血液打進主動脈之後，血壓波之前進，並不是由血液自己往前衝。而這個血液自行往前衝的理論就是現今生理學中教導的血液循環理論。“所有動脈，內臟都是電阻一樣的被動元件”。也是由於對循環系統的不了解，現今之慢性病流行，高血壓，心血管，腦血管病或糖尿病，肺功能退化等器官退化而引發之疾病，成爲現代的殺手。而且多只有保守的症狀療法，而不是根本的復健治療，所以一吃藥就是十幾年甚至幾十年。

（I）十二經診法

遍診法：

我們由現代的科學工具對脈診有了更清晰的了解之後，再回頭來了解前面所述各種傳統的脈診法。由共振式血液循環理論來看全身十二經之遍診法，就很容易理解。每一條經絡都是某一個血壓波諧波在人體上運送之高速公路。十二條經絡把十二個諧波送到相對應的，以及相同諧波共振的器官。只要血壓送到了器官或穴道，在器官或穴道中的動脈只要開一個小口，血就會自動流進附近的組織中去。充滿血液的動脈就像充氣的輪胎，不論在那裡有個小孔，血就自然的流出來了。由此共振式的血液輸送現象，就可以知道，如果高速輸送公路受損，送血到器官的能力變差，則送往器官或穴道的血液及血液壓力波都受阻，那麼器官與經絡就會同時失去脈波，表示器官與經絡同時衰弱，進而生病了；反之亦然, 如果器官生病了，失去共振特性，則會反向干擾經絡的送血功能，也引起對應脈波振動之改變。所以十二經上穴道的振動，就可診得經絡及器官之送血狀況，進而做出正確的診斷了。

（II）三部九候

三部九候在內經中的記載很多，表示特別重視，但在後世並沒有流傳。但後世醫家如程仲齡曾指出“脈有要訣，胃，神，根三字而已”，似乎得到了三部的精髓。

1. 胃：內經指出“胃者，平人之常氣也”。而張景岳更沿伸其內涵“胃氣即人之陽氣，陽氣衰則胃氣弱，陽氣敗，則胃氣散，此即死生之大本也”。

2. 神：張景岳曾說“善爲脈者，貴在察神，不在察形，察形者，形千形萬，不得其要，察神者，惟一惟精，獨見其眞也”。

3. 根：由難經提出“上部無脈，下部有脈，雖困無能爲害，所以然者，人之有尺，譬如樹之有根，枝葉雖枯槁，根本將自生”，故脈之有根與否，是腎中無氣盛衰之重要標誌。醫家必讀“兩尺爲腎部，沉候之六脈皆腎脈也”。這個看法其實與三部直接相通，胃是診斷中部（人），神是診斷上部（天），而根是診斷下部（地）。

我們在測量上部三個穴道時，發現與太淵（寸口脈）相比，第六諧波都大了幾十個 %。顯示身體之上部是有共同的共振頻：第六諧波，而同樣方法發現下部的三個穴道與寸口脈相比，第二諧波爲下部之共同共振頻。同理，中部的三個穴道與上部或下部比較，則第四諧波，都多了幾十個百分比(%)，表示中部的共同共振頻爲第四諧波(Wang et al. 1989)。

由這個實驗可以知道，三部九候中之三部是有特殊生理意義。應該是到頭上血管之共振頻（第六諧波），到手上血管之共振頻（第四諧波），及到腳上血管之共振頻（第二諧波）。如果丈量由心臟至頭頂，至手心與至腳底之距離，也是接近 1 比2比 3。所以認爲三部爲量測血管之共振波，這也就是個合理的推論，而且也有實驗加以佐證。而十二經則又其分別對應之諧波。這個理論在診斷及治療上之特殊應用請參看（Wang 2002, 2011）。

脈診，疾病與方劑

在內經及張仲景的著作中，脈診與証是結合起來的，對病機、病理都有深入推敲，辨証。而王叔和的脈經中爲了提高脈診的地位，把脈象與主病作了直接對應的處理，使脈象與病成爲單一的對應關係，甚至對處方也做了許多單一的對應。例如：關上脈微浮，積熱在胃中，嘔吐蛔虫，心健忘；關上脈緊而滑者，蛔動；尺脈沉而滑者，寸白虫；脈來過八寸入魚際者遺尿。甚至在平三關病候并治宜第三之文中，將脈與治病藥方也做了單一的對應。這此所謂蛔虫或是長了白蟲，或遺尿。如果由現代的科學論證法，如果沒有蛔虫，沒有遺尿，只要幾個失誤的例子，是否就足以証明脈經是錯了？

而脈經中幾乎用了窮舉法，把所有的可能在寸關尺與二十四脈中的關係，都與各種病症做了一對一的對應。現在看來，這麼多種的變化，這麼多種的病症，只怕三輩子都活九十歲也無法一一遇到，可想而知，脈經只是利用排列組合做做配對的遊戲，並不是眞正由臨床經驗來寫這些書的。

所以由筆者來看，這本書是中華文化中最佳的錯誤樣本，古聖先賢，找到了一個類比的關係，就由這個關係，做了許多的演繹，而用來表達這二個系統間的類比關係。由陰陽五行來推論十二經脈中血液分配的規則，本就不可能完備，只有七至八成的正確。

而後人不做驗證工作，反而將此類比關係無限擴大，也就難免錯誤百出，荒誕不經了。而在本草與方劑學上，因爲沒有受到這些脈診文獻的戕害，反而成了秦漢以來，中醫較有發展的方向。因爲有不斷的人體實驗，不斷的瘟疫，逼得醫家們不能不面對現實，實事求是的認眞面對後果，修正錯誤。所以在漢晉之後的中藥與方劑有孫思邈，李時珍等大師。而不論是根據十二經絡發展出來的中醫基礎理論，或由脈診引導的中醫診斷反而是一片混沌，又回到盤古開天地之前的狀態。而中醫診斷反而在舌診等脈診以外，較能直接驗證的方法上有了長足的進步。

脈診的未來

一個科學的發展，要不斷的驗證。英國的大哲學家法蘭西斯培根，就是主張驗證的倡導者，也是現代實驗科學的創始人，他主張以設計新工具來驗證。雖然他也強調歸納的方式作爲科學推進的手段，但是在歸納的過程，他都一直強調驗證。尤其他對於各種科學的陋習，莫名其妙的崇拜（idols）提出糾正認爲是科技演進的最大阻礙。

他提出四種偶像崇拜（idols）

1) 部落的崇拜（idols of the Tribe）：

人類認知的本能中有些對事物的扭曲，並進入人類的共同知識。陰陽五行的觀念在中華文化中之濫用，以至造成義和團式的文化，就是可怕的例子。

2) 岩洞的崇拜（idols of cave）：

每個人基於自己有限之經驗而相信的事情，或幻想出的理論：例如一些宗教人士或氣功大師，總覺得自己得天獨厚，有了不同凡響的神通、神功。

3) 市場之崇拜（idols of market place）：

因爲人們一再的口耳相傳，眾口爍金，以至積非成是，臺灣的選舉時的大型造勢，藍綠對立，可說是政客利用市場崇拜最佳例子。

4) 劇場的崇拜（idols of theater）：

世界本就是個劇場，而過去的經驗知識，就累積在教科書，書本，電影，小說之中，如果這些過去的經驗，並未經過驗證，就可能是個錯誤的展示或演出，不可不慎。而現代傳統文化所製造的歌星、影星，更是劇場崇拜的典型。

而要維持這些崇拜，必需經由驗證，是正確的才值得崇拜。

在培根之前，東西方之經濟及文明的差異不大，西方經濟及文明主軸在義大利爲主的歐陸，而東方在中國。培根的影響擴大後，西方文明的中心由義大利移到英國，進而發生工業革命，並造就了大英帝國。西方在文藝復興之後，經濟、文化的發展開始與宗教脫鉤，但卻在工業革命時才眞正開花結果，將科技的成就落實到日常生活，以及每天的生產中來。

培根的哲學促進西方的經濟及文化做了跳躍式的提昇。是否有我們可以借鏡的地方？

本文借花獻佛，僅對脈診的未來做一些建議。

以客觀（工具）的驗證爲規，以歸納法爲矩，驗證新的，一切過去脈診的說法。並開拓對各種健康狀態的診斷及對各種疾病之療法之新的評估。打破脈診以演繹爲主（如脈經），只以窮舉法把所有可能，一網打盡，不去驗證，也不歸納爲簡單可遵循的法則。

我們經過了大量的實驗，提出了一個脈診的工具，這就可以做進一步的驗證的基礎，也可作爲進一步去蕪存菁的開始。而在中醫基礎理論上，也將十二經絡的定義與脈診之原理結合爲一。

我們只是推出了我們經過驗證及歸納後，得到的十二經絡的生理基礎，並因此製造了脈診儀作爲工具。這個客觀，一切不假手指觸覺的工具，可以作爲脈診未來發展的起點。因爲是全機械操作，數據很容易再現。因爲操作簡單，驗證變成容易。因爲沒有觸覺，沒有主觀判斷。不需要長時間的訓

練、學習，因而容易普及。因爲相同的現象也發生在動物，許多驗證工作就可大規模地以動物來做，而加速驗證的效率。

可以脈診原理了解單味藥的作用，並進而開發新的處方，以診治現代的各種流行疾病，尤其是代謝性的慢性病。

以脈診原理，用動物實驗研究單味藥之有效成份。以脈診原理，用動物實驗研究中藥能夠改善各個特定臟腑血液循環之藥理。以上幾個具體的方向，希望拋磚引玉，引發大家新的思考，新的方向。

讓我們一起來參與，以期待一個新的健康革命，像工業革命一樣，爲人類文明開展另一個全新的開始。

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