Pulse Spectrum Analysis in 205 Patients with Abnormal Liver Function Test

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Background and Purpose: Pulse analysis is non-invasive and very popular in traditional Chinese medicine clinics. The aim of this study was to evaluate the possibility of pulse diagnosis. **Methods:** We carried out pulse spectrum analysis on 205 patients with possible liver diseases. Correlation between liver tests, which included T-Bil, D-Bil, SGOT, SGPT, ZTT, Alp, γ-GT, Cho, AlB and AlB/Glo, and ultrasound scanning were analyzed. We used six criteria for pulse diagnosis of liver abnormality to test for correlation. These were (1) C1≧3 and C1 + C4≧4 or C1+C6≧4 (in intensity), (2) C1≦-3 (in intensity), (3) C6≧3 and C1+C6≧4 (in intensity. (4) C6≦-2 (in intensity) and C6≦-2 (in phase), (5) C1≧2 and C3≦-2 (in intensity) or C3≦-2 (in phase), and (6) C3≦-2 (in intensity) and C3≦-2 (in phase). For the intensity, C1 (liver) every 5% above normal was given one "＋", every 5% below normal was given one "－". For C3 (spleen), C4 (lung), C6 (gallbladder), every 10% above normal was given one "＋", every 10% below normal was given one "－". For the phase, every 10% delay in the traveling speed of the pressure wave was given one "－". **Results:** Only the "＋", "N" (N = normal) and "－" states were considered, while quantities of "＋" "－" were neglected. In pulse analysis, there are 311 (from intensity) × 311 (from phase) ＝ 177, 147 × 177, 147 possible states (3 qualitative states and 11 harmonics). We considered only six criteria for liver abnormality and the correlation was very high, $p < 0.001$, Kappa = 0.68. **Conclusion:** The results strongly suggest that pulse diagnosis theory has physiological and pathological importance, and is worthy of further study in the future.

Key words:pulse diagnosis, spectrum, fourier tran-sform, harmonic

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Introduction

Blood tests and ultrasound scanning are standard techniques for the diagnosis of liver problems. Indicators such as SGOT (serum glutamate oxaloacetate transaminase), SGPT (serum glu-

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tamate pyruvate transaminase) are related to the damage and leakage of liver cells. However, there is no easy assessment of how liver problems affect other parts of the body,[1] such as the spleen, stomach, lung and gallbladder. We report on patients who visited the hospital for possible liver problems, with the goal of using pulse spectrum theory to diagnose liver problems and evaluate the possibilities of pulse diagnosis.

In our previous report on pulse analysis of patients with severe liver problems, we found that the spleen meridian and the liver meridian were closely related to liver problems, which might be induced by virus or alcohol.[2] Data on that study was gathered from regular check-ups, and all the subjects suffered from liver cirrhosis. In this study, the subjects were patients who came to the hospital because of discomfort or liver problems. Pulse diagnosis was carried out on 138 patients diagnosed with possible liver problems and 85 patients with the same problem that were included in our previous report.[3] Following our previous investigations, we again used the liver meridian, spleen meridian, lung meridian and gallbladder meridian as markers in pulse diagnosis, since they are closely related to the liver in physiology[4-8] and in the Yellow Emperor's Canon of Internal Medicine.[9]

Material and Methods

Subjects

Between August 1994 and July 1997, patients with liver disease or discomfort of unknown etiology that came to the hospital for treatment were included in this study. Comparison between two groups of tests was carried out (all tests were performed at Taipei City Hospital, Heping Branch). One group of tests included blood tests and ultrasound scanning. The other group of tests was the radial pulse test. The Institute Review Board of Taipei Municipal Ho-Ping Hospital approved the study. All procedures were fully explained to the subjects and informed written consent was obtained from each subject prior to the study. Medical and activity histories were obtained by questionnaire.

Blood Tests

Blood tests included SGOT, SGPT, D-Bil (Direct Bilirubin), T-Bil (Total Bilirubin), Alp (alkaline phosphates), γ-GT (γ-glutamyl Bilirubin), ZTT (Zinc sulfate turbidity), Cho (cholesterol), Alb (albumin) and Alb/Glo (albumin/globulin). Abnormalities from blood tests were noted.[1] The following values were considered abnormal: SGPT >35 IU/L (6-35 IU/L); SGOT >30 IU/L (0-30 IU/L); D-Bil >0.4mg/dL (0.1-0.4mg/dL); T-Bil >1.0mg/dL (0.1-1.0mg/dL); Alp >220IU/L (75-220IU/L); γ-GT >45IU/L (5-45IU/L); ZTT >12 Kυ-u(3~12 Kυ-u); CHO>250 mg/dL or CHO<120 mg/dL (120-250mg/dL); Alb <3.5 gm/dL (3.5-5.0 gm/dL); Alb/Glo <1.0 (1.0-1.5).

Radial Arterial Pulse Tests

The pulse was measured and analyzed during the patient's first visit to avoid the effects of

hunger.[10] (It is routine to ask patients to fast prior to drawing blood for testing.) We selected those patients who told us that they had not taken any medications within the last three days. Procedures for pulse analysis were similar to our previous experiments.[2,3,11] The radial artery pressure pulse of both hands were recorded with a pressure transducer (PSL-200GL, Kyowa Electronic Instrument Co. Ltd., Minato-ku, Tokyo, Japan) fixed on the skin with tape and an adjustable belt with a small button to achieve suitable pressure. The criterion of a good measurement was to seek the largest pulse amplitude. The subjects were first asked to rest for 20 minutes prior to four consecutive pulse measurements being recorded. The output of the pressure transducer was stored in an IBM PC after A/D conversion at a sampling rate of 430/sec. The pulse spectrum was analyzed by the Fourier transform using the period equal to one pulse, as described earlier.[12] This analysis gave spectrum readings up to the 10th harmonic. The intensity of harmonics above the 11th was very small and thus not recorded. Intensity and phase were compared to a male standard (the average of 100 male college students, aged 18 to 20 years) and a female standard (the average of 100 female college students, aged 17 to 19 years). Normal was defined as those who had no known health problems. The criteria for abnormal measurements followed the criteria used in our previous reports.[2,3] We had six criteria for abnormal liver function:

(1)$C_1 \geqq 3$ and $C_1+C_4 \geqq 4$ or $C_1+C_6 \geqq 4$ (in intensity)

(2)$C_1 \leqq -3$ (in intensity)

(3)$C_6 \geqq 3$ and $C_1+C_6 \geqq 4$ (in intensity)

(4)$C_6 \leqq -2$ (in intensity) and $C_6 \leqq -2$ (in phase)

(5)$C_1 \geqq 2$ and $C_3 \leqq -2$ (in intensity) or $C_3 \leqq -2$ (in phase)

(6)$C_3 \leqq -2$ (in intensity) and $C_3 \leqq -2$ (in phase)

A phase angle delay of 10% (i.e. the traveling speed of this harmonic) was mainly due to a structural change in the meridian or its related organ.[12,13] For the intensity, the definition was the same as we used previously. For C_1 (liver), every 5% above normal equaled one "＋" and every 5% below normal equaled one "－". For C_3 (spleen), C_4 (lung) and C_6 (gallbladder), every 10% above normal equaled one "＋" and every 10% below normal equaled one "－".

Statistical Analysis

The blood test was used as the golden standard. The validity of pulse spectrum analysis was analyzed by kappa value and χ^2 test.

Kappa value (κ) = Actual Agreement beyond chance

Potential Agreement beyond chance

When κ = 0~0.2: slight agreement; 0.2~0.4: fair; 0.4~0.6: moderate; 0.6~0.8: substantial; 0.8~1.0: almost. In the χ^2 test: $\chi^2 = \Sigma[(O-E)^2/E]$, where O is observed value; E is the expected value. From the χ^2 value, we could find out the p value, the chance of non-correlation.[14-16]

Results

Two hundred and twenty three patients with liver diseases or discomfort of unknown etiology were included in this study. They (130 males and 93 females between 16 to 85 years of age, average 42.7 ± 11.6 years) came to the hospital for treatment. Two hundred and five out of the 223 subjects had abnormal liver functions. The results for all 223 patients comparing the six pulse criteria with the blood tests and ultrasound scanning are shown in Table 1. The results show that the correlation was very high with $p < 0.001$ and Kappa = 0.68. Results for the 199 patients with abnormal liver functions and pulse tests, split into separate pulse diagnosis criteria, are shown in Table 2. Numbers without parentheses in the Tables are the observed values, where as numbers within parentheses are expected values. The "subject total" gives the number of patients with the criterion in either the left- or the right-hand radial arterial pulse. There was no significant correlation of the abnormal liver functions between pulse diagnosis and viral hepatitis, or between pulse tests and non-viral hepatitis.

Discussion

In our last study,[2] the main etiology of liver cirrhosis was chronic hepatitis B, and only a few were alcohol related. The 24 patients with liver cirrhosis had splenomegaly, abdominal wall venous collaterals and different degrees of ascites in clinical associations. Our previous reports clearly indicated that the lung and liver meridians were good indicators at the transient stage of abnormality, the spleen meridian became a good indicator at the severe stage of abnormality, and other related meridians such as the gallbladder may also be affected.[2,3,10,11] These findings also strongly suggest that the related organ i.e. the lung, and the lung meridian, which is the first target, is affected in mild liver disease and might be induced by chemical poisons that enter the human body through the air. The spleen and the spleen meridian, which is related to the blood composition and circulation, were affected by severe liver problems.

From Table 1. the p values correspond very well with the kappa values. There are 11 harmonics (from 0 to 10th harmonic) in the spectrum analysis. Each indicator may be in an "N","+" or "−"

Table 1. Agreement between pulse diagnosis and the standard tests.

Liver function	Pulse spectrum		Subject total
	Abnormal	Normal	
Abnormal (n)	199 (188)	6 (17)	205
Normal (n)	5 (16)	13 (2)	18
Subject total (n)	204	19	223

n: number of person.
$\chi^2 = 75.824$, P = 0.000000000000535, Kappa = 0.68

state, with different quantities. Even if we do not consider the quantitative results but just focus on the states, there are a total of 3^{11} (from intensity) $\times 3^{11}$(from phase) = 177,147×177,147 possible states.

In this study, we chose just a few criteria from the billions of possible states and obtained good correlation. This result strongly suggests that the pulse diagnosis theory of traditional Chinese medicine contains physiological and pathological importance.

As stated in the introduction, most of the subjects in this study had liver diseases. Two hundred and four patients out of the 205 subjects showed liver function abnormalities with at least one of the pulse tests. It was reasonable that the more criteria we chose in the pulse spectrum analysis, the better the correlation would be. From Table 2. the patients with abnormal liver functions possessed one or more criteria in the pulse diagnosis and this indicated that the liver and gallbladder meridians were important indicators at the chronic stage of abnormality. This finding is consistent with the close relationship between the liver and the gallbladder in physiology.[4-8] Also, this is consistent with the statement in the Yellow Emperor's Canon of Internal Medicine that, "the liver and the gallbladder are superficies and interior for each other." So this study should not only be considered as merely a correlation study of pulse diagnosis in cases of possible liver diseases but also a classification of pulse spectrums in patients with liver diseases. Pulse diagnosis of hepatitis B and hepatitis C is worthy of further study in the future, in spite of no significant correlation between pulse diagnosis and viral hepatitis in this study. The etiology of liver disease in the 205 patients was mostly chronic hepatitis B, and only a few had chronic hepatitis C. This might be the reason for no significant correlation between pulse diagnosis and viral hepatitis.

With a blood test is an indication of a specific problem. With pulse spectrum analysis, we are in the same situation such that each

Table 2. Number of patients who fit into each criterion of pulse diagnosis

Criterion of pulse spectrum	Intensity	Phase	Subject total
1. (A)	C1>=3 , C1+C4>=4		45
1. (B)	C1>=3 , C1+C6>=4		70
2.	C1<=-3		25
3.	C6>=3 , C1+C6>=4		24
4.	C6<=-2	C6<=-2	50
5. (A)	C1>=2 , C3<=-2		55
5. (B)	C1>=2	C3<=-2	41
6.	C3<=-2	C3<=-2	68

criterion of pulse spectrum should have its own pathological and physiological meaning in relation to the meridian. The spectrums are related to different organs and the 12 meridians, distributed in different organs of the body, each has its own physiological function and pathological roles (the Yellow Emperor's Canon of Internal Medicine).[9]

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原 著

205位肝功能異常病患脈波頻譜之分析

呂萬安[1,2,3,4]

目的：把脈是傳統中國醫學臨床上非常流行且非侵入性的方法，本研究之目的正是探討將把脈作為診斷的可行性。**方法：**選取223位疑似肝病病患進行研究，以6個脈波頻譜指標作為肝異常的脈診指標，分析這六項脈診指標與現代醫學各項肝功能檢查(各項肝功能指數包括T-Bil, D-Bil, SGOT, SGPT, ZTT, Alp, r-GT, Cho, AlB, AlB/Glo)以及超音波掃描的相關性，這六項脈診指標分別為(1)第一諧波強度大於等於3且第一諧波與第四諧波強度之和大於等於4，或第一諧波與第六諧波強度之和大於等於4；(2)第一諧波強度小於等於－3；(3)第六諧波強度大於等於3且第一諧波與第六諧波強度之和大於等於4；(4)第六諧波強度小於等於－2且第六諧波相位小於等於－2；(5)第一諧波強度大於等於2且第三諧波強度小於等於－2，或第三諧波相位小於等於－2；(6)第三諧波強度小於等於－2且第三諧波相位小於等於－2。第一諧波(肝)之強度每高於正常值的5%則定量為一個 "＋"，反之每低於正常值的5%則定量為一個 "－"；第三諧波(脾)、第四諧波(肺)、第六諧波(膽)之強度每高於正常值的10%則分別定量為一個"＋"，反之每低於正常值的10%則分別定量為一個"－"；至於相位部分，所有諧波之壓力波傳送速度每低於正常值的10%則分別定量為一個 "－"。**結果：**當不考慮 "＋"、"－" 的變化量而僅考量 "＋"、"N" 及"－"三種情況，那麼11個諧波總共可產生311(強度)×311(相位)＝177,147×177,147個脈波頻譜，本研究僅選用6個脈波頻譜作為肝異常之指標，卻得到非常高之相關性，p值小於0.001，Kappa值等於0.68。**結論：**這個結果顯示脈診學說具有生理與病理上的重要性，將來值得進一步去深入研究。

關鍵詞：脈診，頻譜，傅立葉轉換，諧波
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