

Influence of Spleen Meridian Herbs on the Harmonic Spectrum of the Arterial Pulse

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Abstract: Pulse analysis is a powerful method in Chinese medicine. We suggest that the effect of herbal medicine is to redistribute the blood to organs and meridians. In this report, by injecting extracts into rats and then analyzing the blood pressure wave measured at the caudate arteries, we studied eight important spleen meridian related herbs: They were *Semen Lablab*, *Fructus Amomi Globosi*, *Rhizoma Atractylodis Macrocephalae*, *Rhizoma Atractylodis*, *Tuber Pinelliae*, *Radix Codonopsitis*, *Pericarpium Aurantii* and *Rhizoma Polygonati*. All eight herbs increased the intensity of the 3rd harmonic (C3) of the pressure pulse which is correlated to the spleen and spleen meridian, as described in traditional Chinese medical literature. All of them also increased the 2nd harmonic (which is correlated to the kidney and the kidney meridian) as well as decreased the heart load (DC term of pressure wave, C0). *Tuber Pinelliae*, *Radix Codonopsitis*, *Pericarpium Aurantii* and *Rhizoma Polygonati* decreased the 1st harmonic (correlated to the liver meridian) significantly, while *Rhizoma Atractylodis Macrocephalae* only decreased C1 slightly. Except for *Semen Lablab*, all the others decreased the intensity of the 5th (stomach meridian) and the 7th harmonics. The effects of kidney herbs: *Cortex Eucommiae* and *Radix Achyranthis* were also shown for comparison.

In our previous studies on hemodynamics, we developed a blood pressure wave resonance theory for the circulation system (Wang *et al.*, 1989a; Wang Lin *et al.*, 1991, 1997) to describe the behavior of the pulse shape. We suggested that each organ is coupled with the aorta and is in resonance with a specific frequency, which is the harmonic of the arterial pressure pulse. The acupuncture points of the same meridian are a group of arterial trees linked to the artery (the artery near the accupoints). They couple with the artery and resonate with the same frequency as their related organ. The pressure pulse will then propagate mainly at that specific frequency along the meridian since it is minimally attenuated at the resonant frequency. Therefore, the pulse shape of the pressure wave in a large artery is the integrated behavior of the entire circulatory system, which includes all the organs and the

meridians. It can reveal the energy distribution in the body and the health condition. Any changes of the resonance condition of an organ or acupuncture point will influence the pulse spectrum, which is correlated to the blood distribution to organs and meridians (Wang *et al.*, 1989b; Young *et al.*, 1989, 1992). From a series of studies (Wang *et al.*, 1989a; Young *et al.*, 1989, 1992; Yu *et al.*, 1994), we found the 1st harmonic (C1) is correlated to the liver and the liver meridian, the 2nd (C2) to the kidney and the kidney meridian, and the 3rd to the spleen and the spleen meridian.

In order to understand how herbs affect the pressure pulse, we used the pulse analysis method to study many meridian-related herbs and widely used formulas (Wang Lin *et al.*, 1992; Wang *et al.*, 1995b, 1996b, 1997, 1998). *Ganoderma lucidum*, which is described as having the effect of increasing 'Qi,' increases the amplitude of the 3rd, 6th and 9th resonance frequencies in human subjects. *Panax ginseng* increased the 3rd, 4th and 5th harmonics, and *American ginseng* increased the 4th and 5th harmonics (Wang *et al.*, 1994a). According to "Pen-Tsao Be-Yio," *Panax ginseng* is good for spleen, lung and stomach and *American ginseng* is good for lung and stomach. In another study the traditional replenishing 'Kidney Yin' formula, Liu-Wei-Dihuang (Wang *et al.*, 1998), showed significant effects on the 3rd, 1st, and especially the 2nd harmonics, and the 2nd harmonic is related to the kidney meridian (Yu *et al.*, 1994). All these results are in agreement with the description in the traditional Chinese literature if we correlate the 1st, 2nd and 3rd harmonics of the heart beat to liver, kidney and spleen meridians, respectively. The effects of acupuncture were studied and showed a similar correlation (Wang *et al.*, 1995a, 1996a).

There have been many studies of the effects of herbs related to the spleen meridian. Most of these studies focused on the biochemical ingredients of the herbs, and then gave an explanation of therapeutic effects from a pharmacological perspective (Matsuda *et al.*, 1991; Matsuura *et al.*, 1993; Yasukawa *et al.*, 1995; Li *et al.*, 1997). For example, *Atractylodis Rhizoma* was found to have strong inhibitory effects on kidney ($\text{Na}^+ + \text{K}^+$)-ATPase activity (Satoh *et al.*, 1991). *Pinelliae Tuber* was used to treat childhood pneumonia (Dong, 1990). However, few of these studies could explain the meridian-related effect.

In this study, we use the pulse analysis method to study eight spleen meridian-related herbs: *Semen Lablab*, *Fructus Amomi Globosi*, *Rhizoma Atractylodis Macrocephalae*, *Rhizoma Atractylodis*, *Tuber Pinelliae*, *Radix Codonopsis*, *Pericarpium Aurantii* and *Rhizoma Polygonati*, described in "Pen-Tsao Be-Yio," and show that all of them could increase the 3rd harmonic which is correlated with an increase in blood flow to the spleen meridian and therefore replenishes the spleen meridian. This may give a direction for research in Chinese medicine.

Materials and Methods

Herb Extract Preparation

All herbs were obtained from the local Chinese herb store. Five grams of herb was soaked in 20 g of water, then heated to 100°C for 15 mins, and kept at 80°C for 1.5 hrs. Evaporation was kept to a minimum. Dosage was: *Semen Lablab* (2.8 mg/g), *Fructus Amomi Globosi* (1.1 mg/g), *Rhizoma Atractylodis Macrocephalae* (1.3 mg/g), *Rhizoma Atractylodis* (1.8 mg/g), *Tuber Pinelliae* (1.1 mg/g), *Radix Codonopsis* (1.2 mg/g), *Pericarpium Aurantii* (1.8 mg/g), *Rhizoma Polygonati* (1.8 mg/g).

STUDY OF SPLEEN MERIDIAN HERBS

Animal Experiment

Wistar rats, 200–300 g, were anesthetized with urethane before operation. The tail artery was cannulated with an intravenous catheter filled with physiological saline and heparin, and then connected to a pressure transducer (RP-1500 Narco Biosystem). The blood pressure wave from the artery was measured and recorded through the transducer, which was in series with a preamplifier, AD converter and personal computer. The pressure wave was then analyzed.

After the cannulation, 40 mins or more was allowed for stabilization before data collection began. Five to seven consecutive pressure pulses (about one second) were taken every two minutes and were averaged as one data recording. Recordings were taken for a half hour, and the average value was used as the pretreatment control. The herbal extract was then injected intraperitoneally, and posttreatment recordings were taken for three hours continuously. The signals were then analyzed by the Fourier analyzer.

Two criteria were used to judge a good experiment: (1) A recording was not used if the coefficient of variation (CV) of the heart rate for five to seven consecutive pulses exceeded 5%. (2) For recordings in the pretreatment interval, the CV of the heart rate and the harmonic proportions of the recordings for the first three harmonics plus the DC term could not exceed 5%; for harmonics 4,5,6 and 7, 10% was the margin.

Results

The effects of the herbs on the pulse spectra were expressed as the percentage difference of harmonic proportions between post- and pretreatment defined as:

% Difference of harmonic proportion = $100 * [C_n(T_i) - C_n(T_0)] / C_n(T_0)$. C_n is the n th harmonic proportion = (A_n/A_0) for $n = 1$ to 7, where A_n is amplitude of the n th harmonic of the pulse spectrum, A_0 is the DC component of the pulse spectrum, and for $n = 0$, we define $C_0 = A_0$. T_i is time after intraperitoneal injection. T_0 is time of control, and $C_n(T_0)$ is the average value of C_n in the pretreatment interval.

Figures 1 to 8 show the effects of *Semen Lablab*, *Fructus Amomi Globosi*, *Rhizoma, Atractylodis Macrocephalae*, *Rhizoma Atractylodis*, *Tuber Pinelliae*, *Radix Codonopsis*, *Pericarpium Aurantii* and *Rhizoma Polygonati* respectively. On each figure, data from eight rats were averaged, and there are six curves corresponding to 30-min-interval averages. The percentage differences of the harmonics proportions from 1 to 7 as well as the DC term are presented. The x-axis equals the control because the percentage differences of harmonic proportions of each half-hour effect was compared with the control data. The standard error and Student's t-test of the 90-120-min curves is also shown.

All of eight herbs increased the 2nd and especially 3rd harmonic proportions and decreased the C_0 (the DC component of the pulse) significantly. *Rhizoma Polygonati*, *Pericarpium Aurantii*, *Radix Codonopsis* and *Tuber Pinelliae* decreased the 1st harmonic proportion in a statistically significant fashion. *Rhizoma Atractylodis Macrocephalae*, *Rhizoma Atractylodis* and *Fructus Amomi Globosi* caused a smaller decrease. The 6th harmonic proportions were typically higher than the 5th and the 7th harmonics, although all three were often below zero. Seven of the eight herbs decreased the 5th and the 7th harmonic proportions significantly; *Semen Lablab* was the exception (Figure 1).

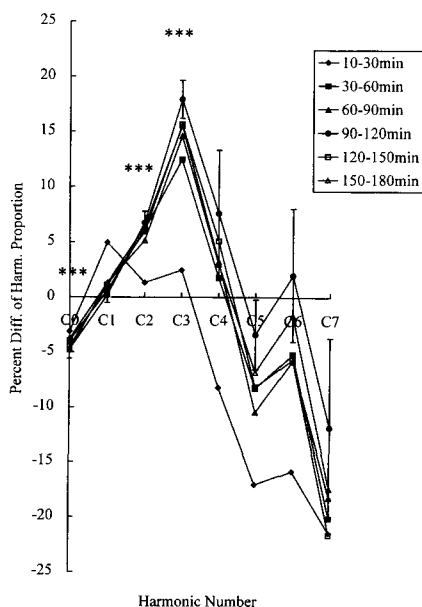


Figure 1. The average effects of *Semen Lablab* on rat pressure pulse ($n = 8$). Shown are percentage differences between post- and pretreatment for harmonic proportions from 1 to 7 as well as the DC term. The six curves correspond to 30-min averages. The x-axis represents the pretreatment control. The standard error and results of Student's *t*-test for the 90-120-min curve are also shown. *: $P < 0.1$, **: $P < 0.05$, ***: $P < 0.01$.

Discussion

We have studied the relation between the blood pressure and flow for years. When we blocked the blood flow to an organ, the corresponding harmonic proportion of the pressure pulse decreased significantly (Wang *et al.*, 1989a; Young *et al.*, 1989, 1992; Yu *et al.*, 1994). Similar tests were conducted on meridians (Wang *et al.*, 1994b; Chen, 1998). We found the change of the blood flow at the acupuncture points of the corresponding meridian followed the change of the related pulse harmonic. The blood flow driven by the pressure pulse was also observed in the microcirculation of the kidney of rats (Jan *et al.*, in print). All the results showed not only the connection between organs and related meridians, but also showed the correlation of pressure and flow.

In this study, the results showed the main function of spleen meridian herbs is to affect the 3rd harmonic of the arterial pulse wave, which, in turn, is correlated with an increase of the blood supply to the spleen meridian. In this way the spleen meridian could get more nutrition and oxygen. These results are consistent with, and provide support for, our suggestion that the spleen meridian resonates with the 3rd harmonic.

Compared with kidney meridian herbs, which also have some effects on the 2nd and 3rd harmonics (Wang *et al.*, 1998), the spleen herbs have a relatively stronger effect on the

STUDY OF SPLEEN MERIDIAN HERBS

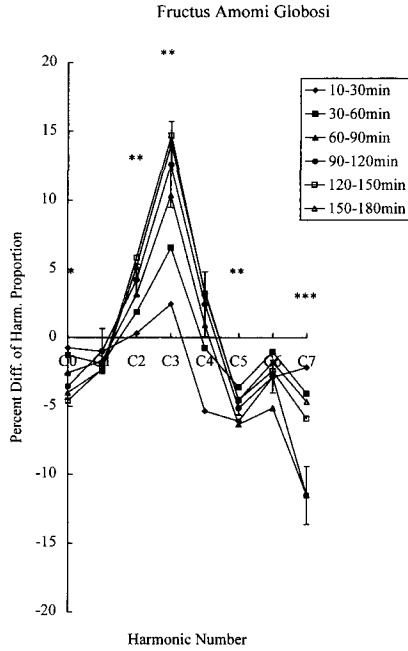


Figure 2. The average effects of *Fructus Amomi Globosi* on rat pressure pulse (n = 8).

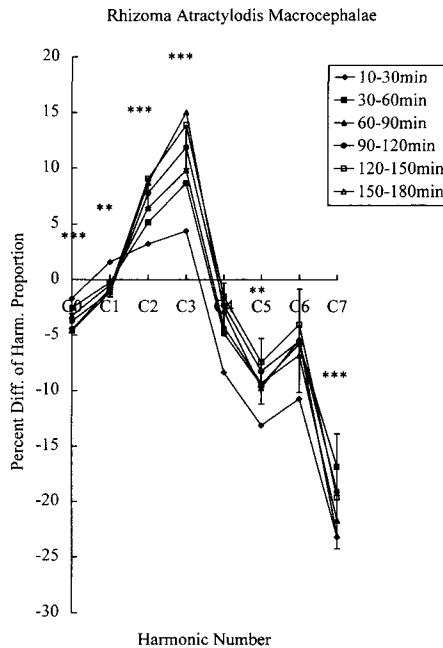


Figure 3. The average effects of *Rhizoma Atractylodis Macrocephalae* on rat pressure pulse (n = 8).

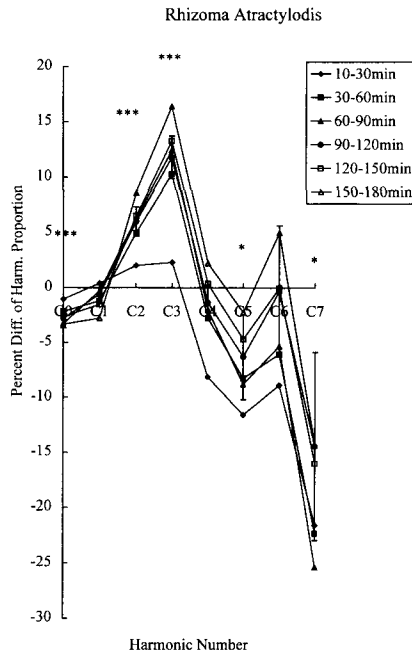


Figure 4. The average effects of *Rhizoma Atractylodis* on rat pressure pulse (n = 8).

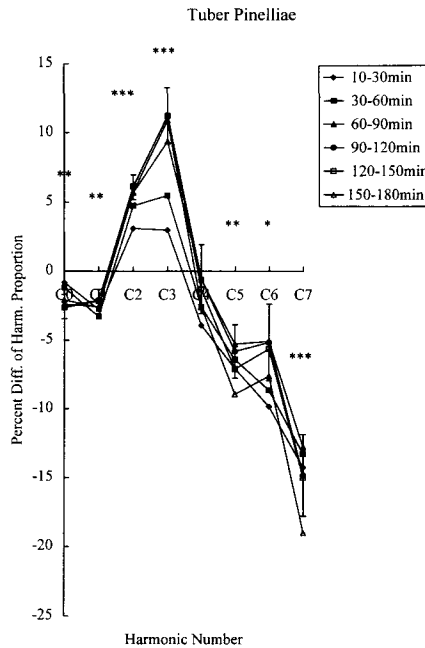


Figure 5. The average effects of *Tuber Pinelliae* on rat pressure pulse (n = 8).

STUDY OF SPLEEN MERIDIAN HERBS

Radix Codonopsis

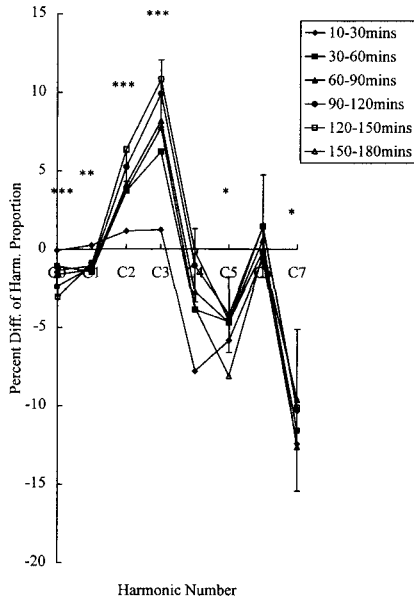


Figure 6. The average effects of *Radix Codonopsis* on rat pressure pulse (n = 8).

Pericarpium Aurantii

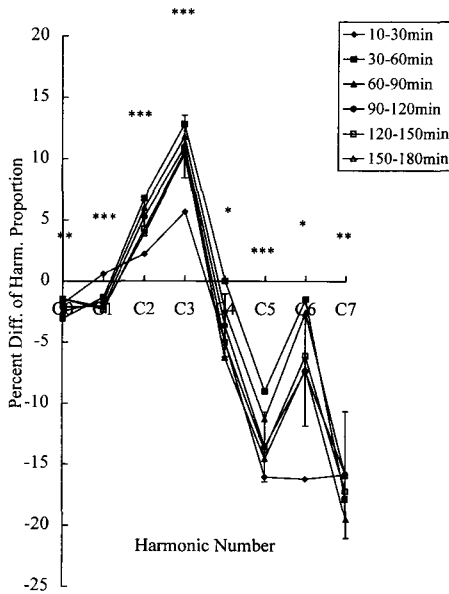


Figure 7. The average effects of *Pericarpium Aurantii* on rat pressure pulse (n = 8).

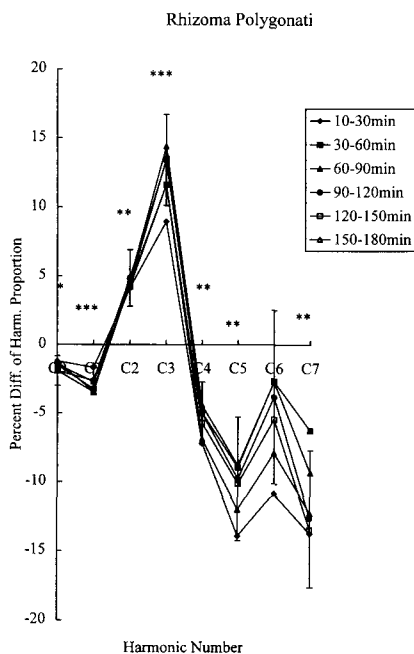


Figure 8. The average effects of *Rhizoma Polygonati* on rat pressure pulse ($n = 8$).

3rd harmonic while the kidney herbs have a relatively stronger effect on the 2nd harmonic, as shown in Figures 9 and 10. Another study (Wang *et al.*, 1994a) showed spleen herbs usually effect the 3rd, 6th and 9th harmonics together in humans. In rats, the spleen meridian herbs usually effect the 3rd and 6th harmonics together (a local peak at the 6th harmonic; the energy at the 9th harmonic is very small), while kidney herbs decrease the higher harmonics (C5, C6 and C7, see Figures 9 and 10). Normal saline didn't have any effect on the pulse spectrum (Wang Lin *et al.*, 1992).

When the results are examined more closely, none of these herbs had the same effect. *Tuber Pinelliae*, *Radix Codonopsisitis*, *Pericarpium Aurantii* and *Rhizoma Polygonati* more strongly decreased the 1st harmonic proportion (the liver meridian, C1), while all of them decreased the heart load (C0). It is not surprising to find that *Rhizoma Atractylodis Macrocephalae* and *Rhizoma Atractylodis* had almost the same effect, because they belong to the same species.

In "Pen-Tsao Be-Yio," *Tuber Pinelliae* is described to have the effect of 'moistening the kidney.' This may be the reason that *Tuber Pinelliae* has a higher effect on the 2nd harmonic.

This study not only strengthens our previous work on the relation between pulse harmonics and meridians, but also implies that herbal medicines may achieve their beneficial effects due to their redistribution of the pulse harmonic spectrum.

STUDY OF SPLEEN MERIDIAN HERBS

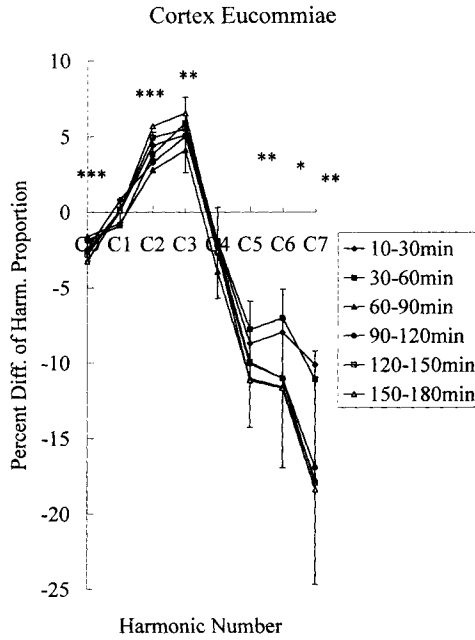


Figure 9. The average effects of *Cortex Eucommiae* on rat pressure pulse (n = 8).

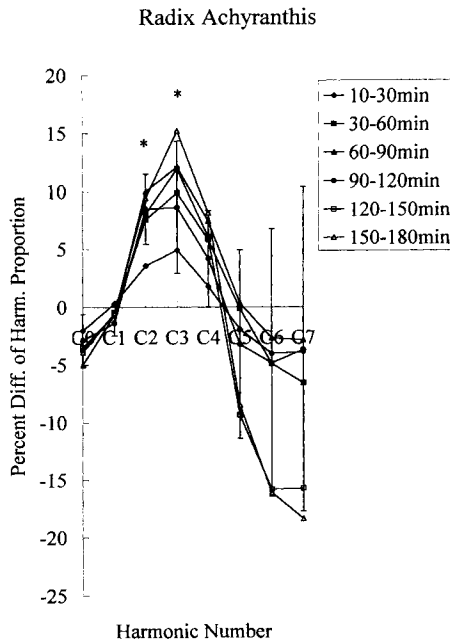


Figure 10. The average effects of *Radix Achyranthis* on rat pressure pulse (n = 8).

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STUDY OF SPLEEN MERIDIAN HERBS

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