American Journal of Chinese Medicine, Vol. XXIV, No. 1, pp. 93-98

The Prandial Effect on the Pulse Spectrum

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(Accepted for publication August 1, 1995)

Abstract: The prandial effect on the pulse spectrum of the radial artery was studied. Ingestion greatly affected the spectrum of the pressure pulse. For most of the tested subjects, the harmonic proportions of the 2nd and the 4th harmonic increased significantly after ingestion, however a decreasing effect was found on the 5th, 6th, 7th, 8th, 9th harmonics. The spectrum became stable from half hour after ingestion and last 3 to 4 hours. From these results, a reliable pulse diagnosis is therefore suggested to be done in the period when the pulse spectrum is stable; physiological significance of these postprandial phenomena is also discussed.

Pulse diagnosis is a unique method in traditional Chinese medicine. A traditional Chinese medicine practitioner assesses the health status of the internal organs as well as the blood and "Chi" distribution around the body by diagnosing a person's pulse. The Chinese medical literature has mentioned that blood and "Qi" vary along different times of the day and suggests that one should do the pulse diagnosis right after waking up and before any activity (*Huang-Ti-Nei-Ching*). This diagnostic timing, however, obviously is not very convenient. Therefore, it is important for us to study the influence of everyday activity on the pulse and give an alternative choice for a reliable time in making the pulse diagnosis. Taking a meal is obviously an important physiological activity. In our previous reports, we suggested that the Fourier components of the pulse are related to the resonant conditions of blood distribution to the organs as well as the tissues (acupuncture points) (Wang *et al.*, 1989a, 1992a, b; Wang Lin *et al.*, 1991; Yu *et al.*, 1994). Detecting the variations of the pulse spectrum can be the basic principle of traditional pulse diagnosis (Wang *et al.*, 1987, 1989b, c, 1994a). We reported that either acupuncture (Wang *el al.*, 1995) or Chinese herbs (Wang *et al.*, 1994b; Wang Lin *et al.*, 1992) could affect the pulse in specific frequencies that were in agreement with traditional medical descriptions. Ingestion activity has been reported to produce very complex physiological responses on many aspects such as secretion (Guth, 1982), neuroresponse (Grundy et al., 1981; Wood, 1981; Morris and Turnberg, 1980), and gastrointestinal tract movement (Weisbrodt, 1981; Chou, 1982). In the present study, we investigated the postprandial effect on pressure pulse spectrum, which will provide a view of the blood distribution of the entire body that is the essence of Chinese medicine.

Material and Method

A. Experimental procedure

Human subjects aged between 23-43 years old in apparent good health were tested in our studies. Fifteen subjects (8 males, 7 females) were studied for postprandial pulse pressure variations. These volunteers were asked not to take any medications 3 days before the experiment. During the test day, they were also asked not to have any alcoholic or caffeinated beverage. A half hour rest was routinely required before the test. Room temperature was kept between 23-25°C. Experiment was conducted as the following:

(1) A 10-12 hours fast preceded the test; subject was asked to fast after dinner of the previous day.
(2) Preprandial control: Each subject was asked to lie down and relax with eyes opened for five minutes. Pulse pressure on the right hand radial artery was then recorded with a pressure transducer (PSL-200GL, Kyowa Electronic Instrument Co. Ltd. Japan), which was fixed on the skin by scotch tape and an adjustable belt with a small button to give suitable pressure on the transducer. Our criterion of a good measurement was to seek the largest amplitude of the pulse. 5-6 consecutive pressure pulses were recorded as a complete preprandial control measurement.
(3) Postprandial measurement: Right after step (2), a breakfast such as milk, soybean milk, fried egg, and bread were provided. There was no restriction on food variety or its intake amount; nonetheless the subject was asked to finish eating in 20 minutes. 40 minutes after the first bite of food, the postprandial pressure pulses were recorded in the same way as in step (2).
(4) Five subjects were investigated for extra 3.5 hours postprandial effect. Six more measurements were taken 30 minutes apart.

B. Data processing

(l) Output of the pressure transducer was connected to an IBM PC via an A/D converter with sampling rate = 430 data points/sec. The pulse spectrum was analyzed with Fourier transform software using T (period) = 1 pulse as described previously (Wang et al., 1992b). Standard deviation of heart rate averaged from five to six consecutive pulses in a measurement was not allowed to exceed 5%. The pulse spectra taken at the postprandial steps were then compared with the pulse spectrum of the preprandial control step. The pulse variation was expressed as percentage differences (%D-HP) of the first 9 harmonic proportions, which were defined as:

$$\% \text{ Difference of nth harmonic proportion } [\%D\text{-}HP(Ti)] = \frac{Cn(Ti) - Cn(To)}{Cn(To)} \times 100\%$$

$Cn = (An / Ao) \times 100\%$
Ti: postprandial step i
To: preprandial control
Cn: nth harmonic proportion
An: The amplitude of the nth harmonic of pulse spectrum
Ao: The DC value of the pressure pulse

Results

Table 1 lists the postprandial effects on pressure pulse spectrum as well as the changes in heart rate. After eating, percentage differences of the 2nd and the 4th harmonic proportions increased in 11/15 and 13/15 subjects, respectively. On the other hand, %D-HP decreased (%D-HP<5%) in most of the subjects in the 5th, 6th, 7th, 8th and 9th harmonics. However, the decreasing and increasing effects of the 3rd harmonic were in equal proportion (5/15). Heart rates showed an increase in all of the 15 subjects (1.8-25.8%).

Table 1. The postprandial effect on pressure pulse

Subject	%D-HP≥5%	%D-HP≤5%	Heart rate
1	2	3, 5,6,7,8,9	78-87
2	2, 4	5,6,7,8,9	71-83
3	2,3,4	1, 5,6,7,8,9	68-73
4	3,4,5	6,7,8,9	62-71
5	4,	6,7, 9	70-79
6	3,4,5, 9	6,7	56-57
7	2, 4	1, 5,6, 8,9	66-71
8	1,2,3,4,5, 8	7	63-75
9	2,3,4, 7	6, 8,9	72-75
10	4	1, 3, 5,6,7,8,9	70-84
11	2	3, 5,6,7,8,9	73-80
12	1,2, 4	3, 5,6,7,8,9	66-83
13	2, 4	5,6,7,8,9	68-81
14	2, 4, 7	5,6, 8,9	68-75
15	2, 4	3, 5,6,7,8,9	65-78

%D-HP: percent difference of the harmonic proportions

Figure 1 shows the averaged %D-HP ± standard error of mean of these 15 subjects for harmonics 1-9.

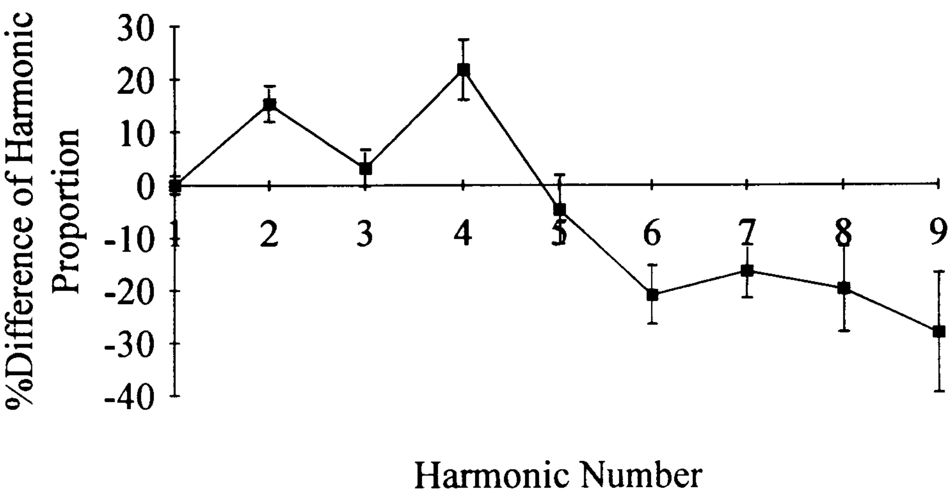

Figure 1. The averaged postprandial effect on pressure pulse spectrum. Pulse spectrum taken at 30 mins after eating was compared with the preprandial control. The averaged percent differences of harmonic proportions ± standard error of mean were presented for harmonics 1 to 9. Harmonic proportions of the 2nd and 4th harmonics increased significantly after ingestion.

The postprandial effects started from 15-20 minutes after eating and lasted 3 to 4 hours. A typical time tracing result is shown in Figure 2.

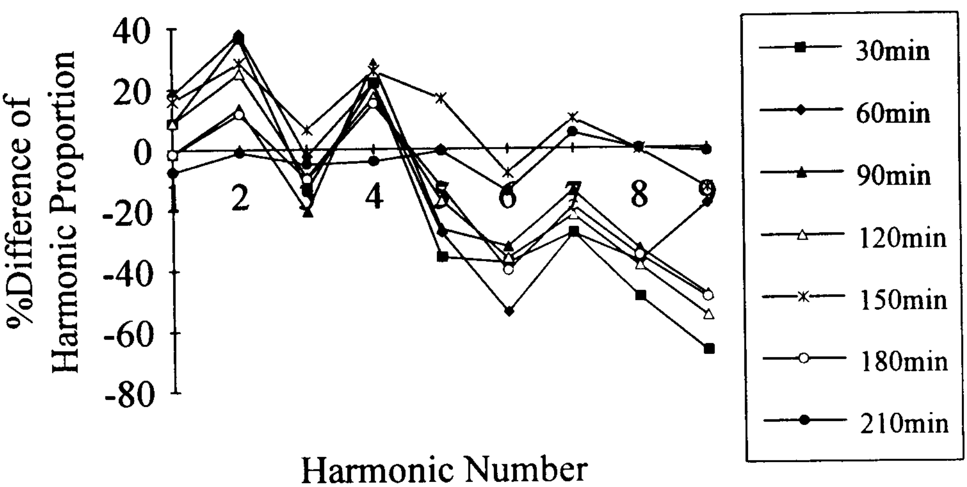

Figure 2. A typical time tracing of postprandial effects on pressure pulse spectrum. Pulse spectral taken at 30, 60, 90, 120, 150, 180, 210 minutes after eating were compared with the preprandial control. Percent differences of harmonic proportions were presented for harmonics 1 to 9. The postprandial effects become stable from 30 to 180 minutes and return to the preprandial control at 210 minutes.

Discussion

We performed several second meal tests, in which a second meal was provided 4 hours after the first meal test. We found similar postprandial effect (data not shown) as described above. A clear pulse-ingestion timing picture was presented here: pulse as well as heart rate varied significantly in the first half hour after ingestion then became stable for 3 to 4 hours until the subject felt hungry, and the pulse returned to the hungry state. It is important for traditional medical practitioners to notice that if a person is hungry, his pulse may appear lower at the kidney (C2) and the lung (C4) meridians (Wang *et al* 1989c; Young *et al* 1989,1992; Yu *et al.,* 1994). The cold feeling of the foot (C2) and hand (C4) during hunger may relate to these lower functional effects (Wang *et al.,* 1989b). The decrease in harmonic proportions of the higher harmonics after ingestion indicates a lower blood distribution to the head, which may also explain why a person feels sleepy after a meal.

The pulse spectrums measured in the morning and in the afternoon were also compared. No significant difference was found between the two (data not shown). The *Zi Wu Liu Zhu* theory (circulation and perfusion of Qi and Xue in early morning and at noon) of Chinese medicine may need further study to clearify the meaning of this finding.

This report suggests that regular physiological activity does affect the pulse. Our findings provide useful information for choosing a suitable time to make a reliable pulse diagnosis.

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