

Effect of Acupuncture Stimulation on Gastric Mucosal Microcirculation

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Summary: The present study investigated the effect of acupuncture stimulation on gastric mucosal hemodynamics. The subjects were 10 males with no abnormalities of the stomach. Laser-Doppler flowmetry was applied for measurement of mucosal blood flow, and the fiberoptic probe of the flowmeter was placed on the gastric antral mucosa of the subjects through a gastroendoscope. The total time of measurement was 10 minutes, and acupuncture stimulation at the point Zusanli (ST36) was performed for 5 minutes during the measurement period. The blood flow of the subjects increased during acupuncture stimulation, and tended to recover to baseline level after removal of the acupuncture needles. The increased blood flow during and after stimulation showed was significantly higher than the baseline blood flow measured with no stimulation. We conclude that acupuncture stimulation at Zusanli (ST36) may be useful for the treatment of gastrointestinal disease on the grounds that it increases the mucosal blood flow.

Key Words : gastric mucosal microcirculation, acupuncture

INTRODUCTION

Although there is no single etiologic factor responsible for gastric ulcers, experimental evidence has accumulated to indicate that mucosal blood flow plays an important role in the pathogenesis and healing of this lesion¹⁻⁸⁾. For the measurement of blood flow of the gastrointestinal mucosa, several techniques such as laser-Doppler flowmetry⁹⁻¹²⁾, hydrogen gas clearance^{13,14)}, and iodoantipyrine clearance¹⁵⁾ have been introduced and widely used in recent years. Among these techniques, laser-Doppler flowmetry is useful

for measurement of gastric mucosal blood flow in humans because it is noninvasive, accurate, and reproducible¹⁶⁾. On the other hand, the effects of acupuncture stimulation on gastrointestinal functions have been demonstrated by several workers, and the value of acupuncture therapy for gastrointestinal diseases such as gastric ulcer has been emphasized¹⁷⁻²⁰⁾. In the present study, changes in human gastric mucosal blood flow by acupuncture stimulation were investigated using a laser-Doppler flowmeter.

SUBJECTS & METHODS

Subjects

Ten male volunteers with no gastric disease, symptoms related to gastrointestinal function, hypertension, or other abnormalities were studied. The mean age of subjects at the time of study was 22.1 years (range, 20 to 26). All the subjects were given informed consent prior to commencing.

Instruments

Figure 1 shows a diagram of the laser-Doppler flowmeter used (ALF-2100; ADVANCE, Tokyo, Japan). The instrument consists of a He-Ne laser (2 mW, 632.8 nm) which is used to illuminate a small spot of gastric mucosa, a fiberoptic probe (fiber separation of 0.5 mm at the tip), and signal processing units. The light from the laser unit is carried to the tissue through the glass fibers, and the backscattered light reflected from stationary tissue and moving red blood cells is carried through the fibers to a

photodetector (a photodiode). The probe (1.8 mm in diameter) is flexible and made for endoscopic use. The electronic system processes Doppler-shifted signals to yield a blood flow value which is expressed as absolute units of ml/min/100 g tissue.

Experimental design

Subjects were fasted for 12 hours before experiments but were allowed to take water. They were pretreated with 200 mg of dimethylpolysiloxane for defoaming the stomach mucosa, intramuscular injection of 20 mg of *N*-butylscopolammonium bromide to inhibit peristole of the stomach, and lidocaine hydrochloride to anesthetize the throat. The gastroendoscope (GIF TYPE V10; OLYMPUS®, Japan) was inserted through a mouthpiece placed between the teeth of the subject to the stomach, with the subject had lying then on the bed throughout the experiment. The flexible optical probe was then inserted into the stomach through

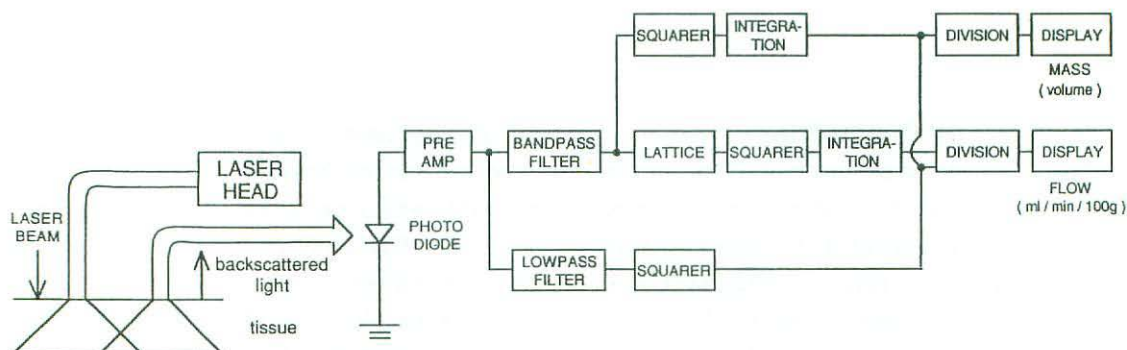


Fig. 1. Diagram of laser-Doppler flowmeter

The instrument (ALF-2100; ADVANCE, Tokyo, Japan) consists of a He-Ne laser (2 mW, 632.8 nm), fiberoptic probe, and signal processing units. The light is carried to and from the tissue through glass fibers which maintain constant fiber separation (0.5 mm) at the tip. The backscattered light which consists of Doppler-shifted light reflected from stationary tissue and moving red blood cells is carried through the fibers to a photodetector (a photo diode). The electronic system yields the blood flow volume from Doppler-shifted signals.

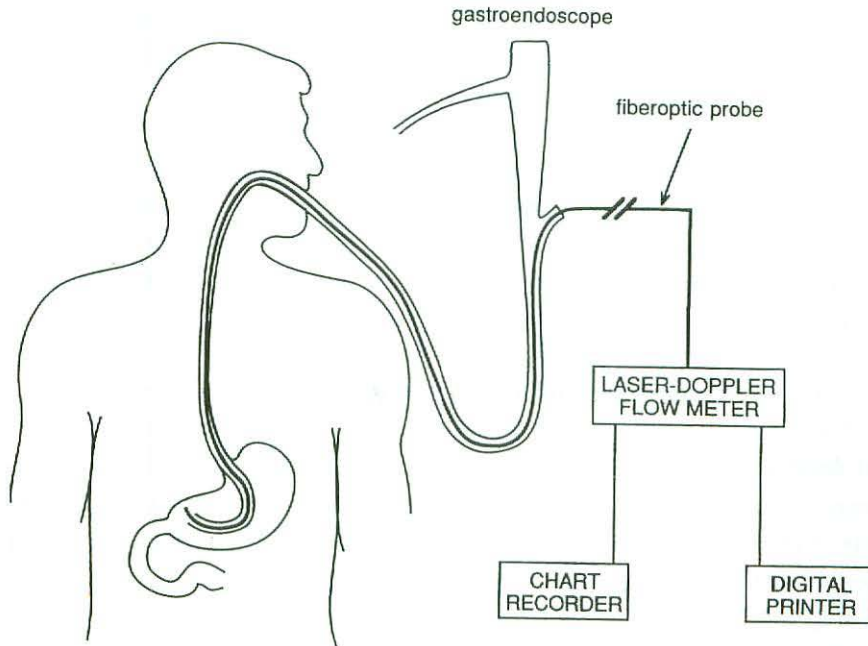


Fig. 2. Measurement of gastric mucosal blood flow

The flexible optical probe was inserted into the stomach and gently placed on the gastric antral mucosa via a gastroendoscope (GIF Type V10; OLYMPUS®, Japan). Blood flow values from the laser-Doppler flowmeter were recorded with a chart recorder (U228; Nippon Denshi Kagaku, Japan) and digital printer (ALF P1; ADVANCE, Tokyo, Japan) as absolute units of ml/min/100 g tissue.

the gastroendoscope and gently placed on the gastric antral mucosa for measurement of blood flow. Blood flow values from the laser-Doppler flowmeter were recorded with a chart recorder (U228; Nippon Denshi Kagaku, Japan) and a digital printer (ALF P1; ADVANCE) in absolute units of ml/min/100 g tissue (Figs. 2 and 3). Two sessions of measurement were performed on each subject; one for measurement of basal gastric mucosal blood flow with no stimulation (controls), and the other to observe the changes blood flow during acupuncture stimulations. The total measurement time was 10 minutes, and acupuncture stimulation

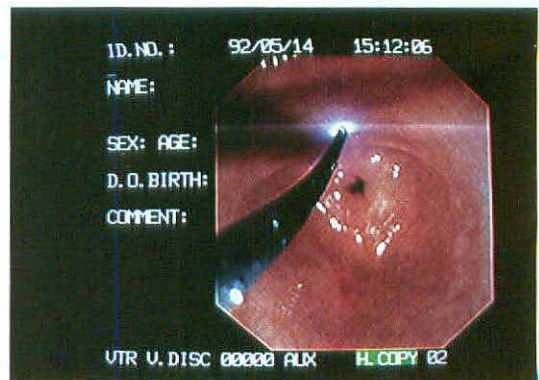


Fig. 3. Contact of fiberoptic probe with gastric mucosa

The fiberoptic probe was placed on the lesser curvature of the antrum, and constant contact pressure and contact angle were maintained.

was performed for a period of 5 minutes (from 2 minutes after the start of measurement to 3 minutes before the end of the experiment). The points stimulated with acupuncture needles (0.20 mm in diameter; ©SEIRIN KASEI Co., Japan) were bilateral Zusanli (ST 36), and the needles penetrated 10 mm. In some of the subjects, we continuously monitored blood pressure simultaneously with measurement of gastric blood flow using a blood pressure monitor (Finapres; Ohmeda BOC Group Inc., USA).

Statistical Analysis

Results were expressed as mean \pm SD in absolute units of blood flow (ml/min/100 g tissue). The blood flow volume in each subject was calculated every one minutes from 24 data points printed at 2.5 second intervals. Differences between controls and the stimulated group were analyzed by Student's t-test, and considered significant if p value was less than 0.05.

RESULTS

The conditions of the subjects were similar in both sessions, and they were kept at rest during the study period. Gastric mucosal blood flow was measured for 10 minutes, and mean flow volume values at every one minute are shown in Fig. 4. Before acupuncture stimulation, the mean blood flow was less than 15 ml/min/100 g tissue with similar

values in the two groups. In the stimulated group, the value of gastric mucosal blood flow increased steadily from the start of stimulation, and showed a peak level of 21.7 ± 7.9 ml/min/100 g tissue at 8 minutes (one minute after removal of acupuncture needles), and then decreased steadily thereafter, but did not return to the baseline level of before stimulation until the end of the measurement. In the control group, blood flow levels did not change throughout the experiments. There were significant differences in the values of blood flow between controls and the stimulated group at 3 minutes (13.4 ± 3.1 vs. 16.6 ± 2.4 , $p < 0.02$), 6

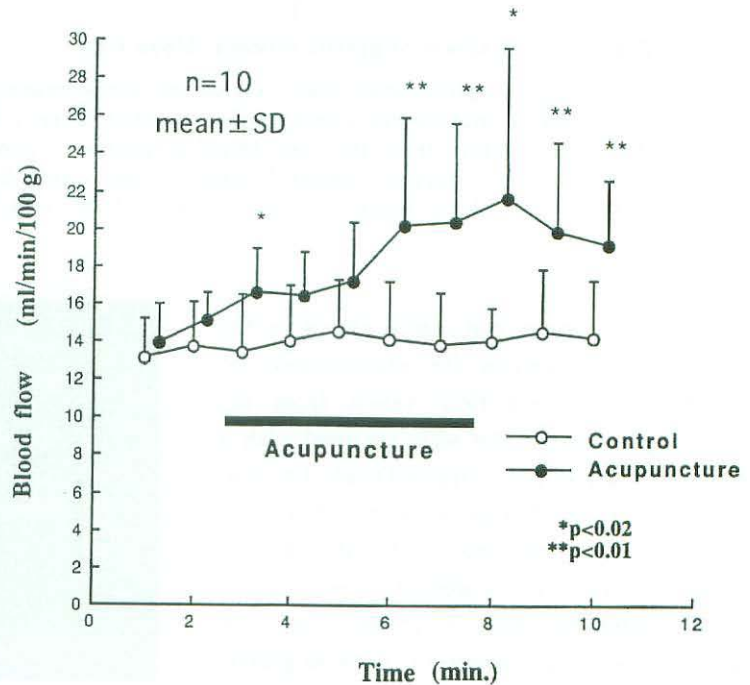


Fig. 4. Mean blood flow values at one minute intervals.

The values of gastric mucosal blood flow increased steadily during acupuncture stimulation, and tended to recover to the basal level thereafter. Significant differences were observed between the two groups at 3, 6, 7, 8, 9, and 10 minutes.

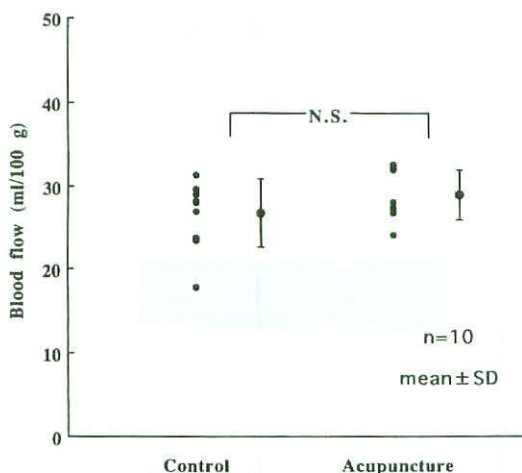


Fig. 5. Total blood flow volume during 2 minutes before stimulation in both groups.

Total blood flow volume before stimulation showed similar level compared with that in the control group.

minutes (14.1 ± 3.1 vs. 20.1 ± 5.8 , $p < 0.01$), 7 minutes (13.8 ± 2.8 vs. 20.4 ± 5.2 , $p < 0.01$), 8 minutes (14.0 ± 1.8 vs. 21.7 ± 7.9 , $p < 0.02$), 9 minutes (14.5 ± 3.3 vs. 19.8 ± 4.8 , $p < 0.01$), and 10 minutes (14.2 ± 3.1 vs. 19.1 ± 3.5 , $p < 0.01$). Figure 5 shows the total blood flow (ml/100 g tissue) during 2 minutes before stimulation in both groups, showing similar values in the two groups. The total blood flow volume during 5 minutes of acupuncture stimulation are shown in Fig. 6. Total blood flow volume during acupuncture stimulation showed a significantly higher value compared with the control period (69.8 ± 13.8 in control group vs. 90.7 ± 16.6 in stimulated group, $p < 0.01$), and a similar difference was also observed in the levels of total blood flow volume during 3 minutes after removal of acupuncture needles (42.8 ± 7.7 in controls vs. 60.7 ± 12.9 in stimulated group, $p < 0.01$) (Fig. 7).

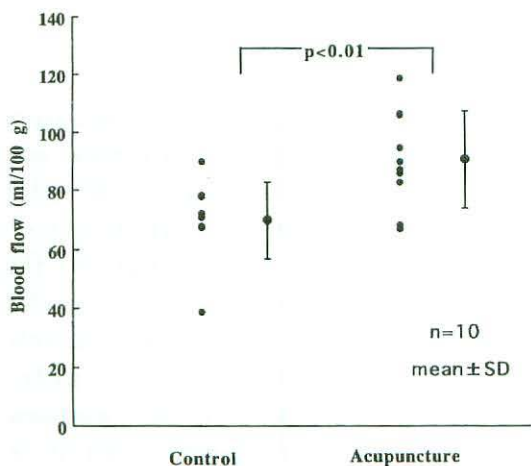


Fig. 6. Total blood flow volume during 5 minutes of acupuncture stimulation.

Total blood flow volume during acupuncture stimulation showed a significantly higher level compared with control values.

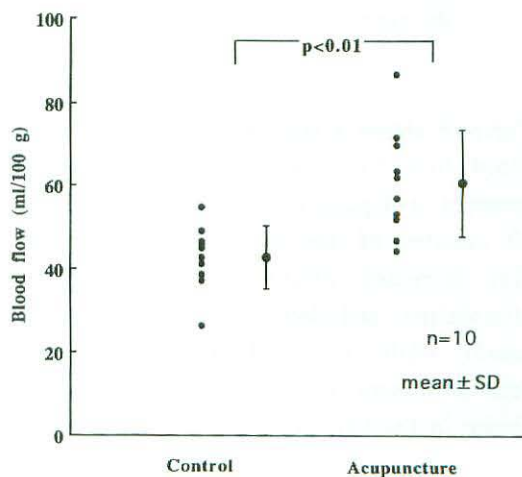


Fig. 7. Total blood flow volume after acupuncture stimulation.

Total blood flow volume after removal of acupuncture needles also showed a significantly higher level compared with control values.

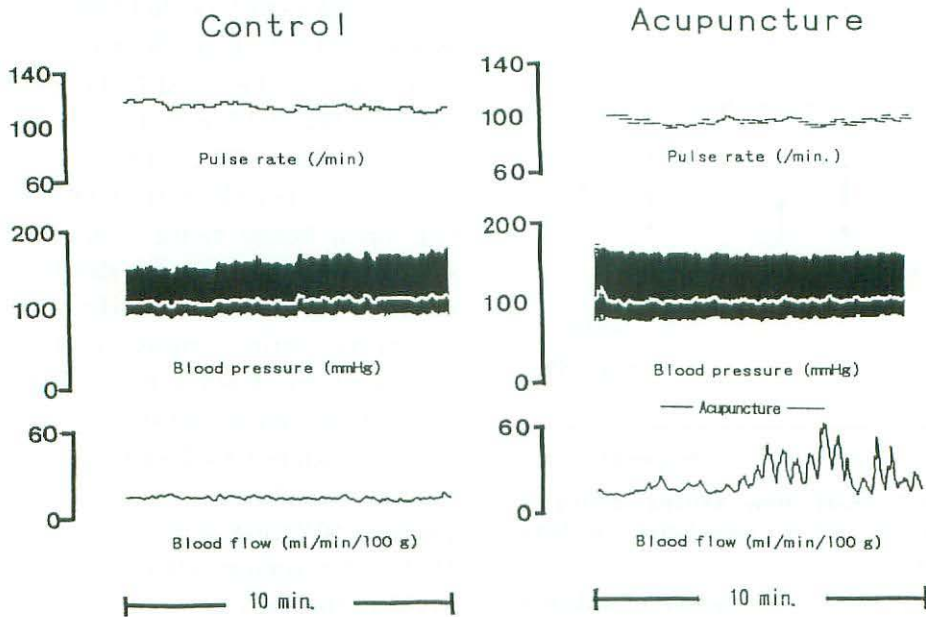


Fig 8. Representative recording during acupuncture stimulation.

The traces of blood flow, blood pressure, and pulse rate in a subject during acupuncture stimulation (right panel) show increase in blood flow by acupuncture stimulation with no effect on systemic blood pressure and pulse rate. On the other hand, the traces in the control period show no changes throughout the 10 minutes of the experiment (left panel).

Figure 8 shows a tracing of gastric mucosal blood flow from the chart recorder, blood pressure, and pulse rate in one subject during 10 minutes of the experiment. The blood flow increased steadily during acupuncture stimulation, and decreased thereafter (right panel), while the blood pressure and pulse rate were similar to the baseline levels as shown in the left panel.

DISCUSSION

The present study showed that gastric antral mucosal blood flow volume were increased during acupuncture stimulation and tended to decrease after removal of the

acupuncture needles, while the stimulation had no effect on systemic blood pressure and pulse rate. These results suggest that this finding was not the result of hypertension or other responses due to the pain of the stimulations but the result of a specific effect of acupuncture stimulation. The role of gastric mucosal blood flow in the pathogenesis of gastrointestinal diseases has been indicated by many experiments, and it is clearly demonstrated that the gastric mucosal microcirculation is important for gastric mucosal protection and healing of gastric mucosal lesions¹⁻⁸). Thus, increased blood flow by acupuncture stimulation may be

effective for the treatment of gastrointestinal diseases such as gastric ulcer. However, the enhanced blood flow in this study may have been the result of increased acid secretion caused by acupuncture stimulation because the supply of energy metabolites for acid secretion of parietal cells which are stimulated by acetylcholine, gastrin or histamine requires adequate mucosal blood flow^{21,22}). Therefore, it is necessary to investigate the change of acid secretion simultaneously with the measurement of mucosal blood flow in the fundic gland area of the stomach during acupuncture stimulation. If increased blood flow with no increase of acid secretion is observed, acupuncture stimulation can be expected to play an important protective role against gastric diseases such as ulcers or erosions. Furthermore, the long-term effect of acupuncture stimulation and the specificity of the stimulating point should be investigated.

One possible mechanism for the increase in blood flow by acupuncture stimulation is that the stimulation caused excitation of the nervous system controlling vasomotion of the gastric mucosa²³). Much evidence has indicated that the autonomic nervous system is primarily responsible for direct control of blood flow to the stomach. Vagus nerve stimulation produces an increase in gastric blood flow by a direct vasodilatory effect on the gastric vasculature^{24,25}), while stimulation of the sympathetic fibers to the stomach results in decreased blood flow^{26,27}). Furthermore, it is clear that a increase in gastric blood flow is also produced by stimulation of the hypothalamus²⁸). Thus, it should be considered that acupuncture stimulation of the lower leg may have an influence on the

hypothalamus or vagus nerve through the dorsal column-lemniscal system or the anterolateral system of the spinal cord^{29,30}) causing an increase in blood flow of the gastric mucosa. Another possibility is that the enhanced blood flow in the present study was evoked by a vasodilator such as biogenic amines (histamine)³¹), gastrointestinal hormones (pentagastrin, octapeptide of cholecystokinin, natural secretin)³²), or prostaglandins^{33,34}). However, the mechanism of release of these agents by acupuncture stimulation at Zusanli (ST36) on the lower leg is unknown. It will be necessary to investigate the release of these agents and the response of the nervous system during acupuncture stimulation.

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胃粘膜血流に及ぼす鍼刺激の効果

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要旨：胃粘膜血流に及ぼす鍼刺激の効果について検討した。対象は胃疾患の既往のない20歳代の健常成人男子10名とした。胃粘膜血流の測定は検査前日の午後9時以降絶食とした被験者に前処置を行った後に胃内視鏡を挿入し、内視鏡の鉗子孔よりレーザードップラー血流計のプロープを胃内に挿入し幽門前庭部の小湾側粘膜に接触させて行った。全測定時間は10分間とし、測定開始2分後より5分間の鍼刺激を行い、刺激終了後3分間までの粘膜血流の変動を観察し、同一被験者における無刺激時の血流変動と比較検討した。鍼刺激には40mm20号鍼を使用し、刺激部位は足三里穴とした。結果、鍼刺激開始後より粘膜血流は徐々に増加し、鍼刺激終了後より前値に復する傾向を認めた。この血流増加は、測定開始後3分、6分、7分、8分、9分、10分の時点で無刺激時と比較して有意であった。今回の結果から、足三里穴への鍼刺激は胃疾患に有用である可能性が示唆された。