Blood Fluidity Enhancement by Electrical Acupuncture Stimulation is Related to an Adrenergic Mechanism

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Abstract
We have reported that electrical acupuncture stimulation (ACU) increases blood fluidity by decreasing platelet aggregation. In this study, we investigated the mechanism causing the increase of blood fluidity. The effects of ACU on blood fluidity and platelet adhesion were examined using a Micro Channel Array Flow Analyzer (MC-FAN) and a laser scattering platelet aggregometer (PA-20).

Male Wistar rats (7–8 weeks old) were used in the study. ACU (1 or 100 Hz, 3–5 V), which causes slight muscle twitching, was applied to the ZuSanli (ST-36) acupoint for 15 or 60 minutes once/day. Blood samples were collected from the inferior vena cava. ACU applied to ST-36 revealed significant increases in blood fluidity, while platelet adhesion activity decreased, regardless of the difference of stimulus time. The acupuncture had an immediate effect. Even if naloxone was administered during acupuncture stimulus, the blood flow time shortened in a similar way, as in the only acupuncture stimulus group. In addition, the effect of acupuncture on blood fluidity was inhibited by a β-antagonist. The results indicate that ACU affects blood fluidity depending on the acupoints, and that the effect of ACU might involve an endogenous adrenergic mechanism.

1. Introduction
Blood fluidity is a very important factor when we think about the drifting of blood flow. It is known that stimuli to an organism influence the autonomic nervous system and the endocrine system, and changes in cardiac function and vascular resistance cause changes in blood flow. It is established that changes in the cardiovascular system will also cause changes in blood properties [1–5]. Changes of blood cell composition and plasma components may influence blood fluidity in the long term [6], and blood cell activity, such as red blood cell agglutination, leukocyte adherence, and platelet aggregation, in the short term [7,8].

It is believed that variations in blood fluidity result in disorders of the circulatory system, such as arterial...
sclerosis or embolism, damage to vascular endothelium cells by hypertension, glucose tolerance degradation and chronic inflammation, degradation of blood vessel flexibility by hyperlipemia and aging, weakness of blood cells, and degradation of plasma plasticity [9,10].

It is assumed that cerebral infarction, myocardial infarction, and pulmonary infarction are caused by an increase of thrombus generation. Common treatments and recurrence prevention for these illnesses include administration of thrombus generation depression medicine, such as warfarin and aspirin [11,12].

The degree of oketsu (Yu xie) is indicated by tongue color and form, swelling, paroxysmal blushing, and dark circles under the eyes [13]. However, these indications do not reflect the real hemogram; oketsu is related to physiological blood flow and is studied from the point of view of blood fluidity and vascular resistance [14–16]. Some studies indicate that some Chinese medicines, for example, toki-shakuyaku-san (Dang Gui Shao Yao San), keishibukuryo-gan (Gui Zhi Fu Ling Wan), and tokaku-joki-to (Tao He Cheng Qi Tang), improve blood flow by vasodilation or blood clotting inhibition [17,18]. In an effort to improve oketsu, in this study we used rats to observe changes of blood fluidity and platelet aggregation ability after applying acupuncture stimuli [19].

Our studies on the effect of electrical acupuncture stimulation (ACU) on blood fluidity have shown that the effects of acupuncture vary according to the stimulus locus (acupoint) of the trunk, the arm or the lower extremities. Our results have also shown that blood flow time is shortened significantly in ZuSanli (ST-36), Hegu (LI-4) and Sanyinjiao (SP-6) stimulated groups, while there are no significant blood flow changes observed when the Neiguan (P-6) and Shenshu (BL-23) acupoints are stimulated. Furthermore, the relationship between acupuncture stimulus and blood cells indicates that the depression of platelet aggregation may be related to erythrocyte deformability or agglutination. The effects of acupuncture stimulus on blood fluidity appear more rapidly than the effects following needle analgesia. As a result, it is probable that the nervous and the secretion systems alter the character and the function of blood cells. The mechanisms that interact between acupuncture stimulus and blood fluidity, however, have not yet been identified. The present study investigated the relation between acupuncture stimulus and length of stimulus time. In addition, the endogenic opioid and the spinal segment analgesic systems were studied to clarify their relevance to acupuncture analgesia, as well as the influence of the adrenaline system on the cardiovascular system.

2. Materials and methods

2.1. Experimental animals

Specific pathogen-free, 7–8 weeks old, male Wister rats were purchased from Japan Bio-Supply Center (Tokyo, Japan). The animals were maintained at 25 ± 2°C, humidity 55 ± 5%, and a light and dark cycle of 12 hours in our animal facilities. The rats were randomly divided into groups of five and fed a regular chow diet and water during the experiments. This study was approved by the Ethics Committee of Showa University for Animal Experiments (00072).

2.2. Blood sampling and anticoagulant

A 3.5 mL blood sample was obtained from the posterior aorta of the experimental rat anesthetized by abdominal injection of pentobarbital (Dainippon Sumitomo Pharma Co., Osaka, Japan) with a 22 gauge needle. Blood samples were collected from the inferior vena cava under pentobarbital anesthesia within 5 minutes of treatment. To obstruct coagulation of the blood, 45 units of heparin sodium was added to 1.0 mL of the sample blood, 2.4 mg of EDTA-2 K to 0.5 mL, and 3.2% of sodium citrate to 2.0 mL.

![Figure 1](image1.png) **Figure 1** Ohm Pulser LFP-4000A. ① Protection ② Frequency ③ Timer ④ Output ⑤ Output 1-4 ⑥ Wave form ⑦ Output intensity.

![Figure 2](image2.png) **Figure 2** The effect of acupuncture stimulus period on blood fluidity. Blood flow time shortened significantly in the two groups with stimulation for 15 or 60 minutes. However, there was no significant difference between the two acupuncture stimulus groups. Data are expressed as mean±standard error of the mean.
2.3. Acupuncture stimulus

The modality of acupuncture needle used was 0.20 × 40 mm (Seirin Co., Shizuoka, Japan). Punctures were pricked at acupoints to apply the needle equivalency locus of humans: ZuSanli (ST-36) on the outside crus superior. ZuSanli was one of the acupoints where the effect on blood fluidity was confirmed [19] and generally is known to improve oketsu [20]. In addition, each control group was anesthetized in the same manner as the experimental groups, but did not receive stimulation. Acupuncture was 5 mm deep and stimulated electrically (3–5 V, 30–200 μA, rectangular and bi-phasic) at a stimulation frequency of 1 Hz or 100 Hz, to permit the muscle to shrink slightly. The stimulus time was 15 minutes or 60 minutes [21]. An Ohm Palser LFP-4000A (Zen Iryoki Co., Fukuoka, Japan) was used as the device of acupuncture stimulus (Fig. 1). LFP-4000A has 4 output lines and is able to stimulate eight points at the same time. It can be useful for electro acupuncture and transcutaneous electrical nerve stimulation.

2.4. Measurement of blood fluidity

We determined the blood fluidity using a Micro Channel Array Flow Analyzer KH-6 (MC-FAN; MC Laboratory Inc.,...
Tokyo, Japan). Coagulation of blood was blocked by heparin sodium. Blood (100 μL) was used to measure the flow time to the silicon tip of the analyzer. We assumed that the flow time in the analyzer imitated the capillary blood fluidity index [22]. In an MC-FAN assay, the prolongation of flow time indicates a decrease of blood fluidity and a short flow time indicates an increase of blood fluidity [23].

2.5. Adjustment of platelet plasma

The blood sample treated with sodium citrate (2.0 mL) was centrifuged (400 g × 5 minutes; Centrifuge5702R; Eppendorf AG, Hamburg, Germany) resulting in a layer of platelet-rich plasma (PRP). The remaining blood was re-centrifuged (2300 g × 5 minutes) to obtain platelet-poor plasma (PPP).

2.6. Blood cell count

We used a PCE-210 (Erma Inc., Tokyo, Japan), an automatic blood cell counter for animals, for complete blood count. Red blood cells, white blood cells, platelets and hematocrit of the EDTA-2 K treated blood samples were counted. PRP was controlled at 3 × 10⁶ /μL by platelet-poor plasma.

2.7. Measurement of platelet aggregation ability

The ability of platelet aggregation was measured with a platelet coagulation measuring system, a platelet aggregometer (PA-20; Kowa Company Ltd., Tokyo, Japan). Controlled PRP (270 μL) in a cuvette was pre-warmed to 37°C. Adenosine diphosphate (ADP; Oriental Yeast Co., LTD., Tokyo, Japan) was added as an agonist and the aggregation level was measured. This PA-20 device can measure platelet aggregation by the light transmission light scattering methods. The light scattering method can measure the platelet aggregate size by determining the intensity of scattered light emitted from a particle, the light intensity directly corresponding to the particle size. The platelet aggregation curve was separately recorded for each size range as the voltage of light scattering intensity. The aggregates measured were divided into three categories according to size: small (diameter 9–25 μm), medium (diameter 26–50 μm), and large-sized aggregates (diameter 50–70 μm) [24,25].

Figure 7 Effect of acupuncture on platelet aggregation measured by the light transmission method. The light transmission (Trans%) of PRP produced from the acupuncture stimulated blood showed a decrease when compared with the control. The decrease of platelet aggregation ability by acupuncture was restrained with β-antagonist.

Figure 8 Effect of acupuncture on platelet aggregation measured by the light scattering method. The light scattering method revealed that large-sized aggregates of the acupuncture stimulated group had decreased significantly as compared with the control. The decrease of platelet aggregation ability by acupuncture was restrained with β-antagonist. Data are expressed as mean±standard error of the mean.
2.8. Drugs and administration method

Phenylephrine (Sigma Chem. Co., St Louis, MO, USA) 200 μg/kg was used as an α-agonist, phentolamine (Sigma Chem. Co., St Louis, MO, USA) 100 μg/kg as an α-antagonist, isoproterenol (Sigma Chem. Co., St Louis, MO, USA) 4 μg/kg as a β-agonist, and propranolol (Sigma Chem. Co., St Louis, MO, USA) 40 μg/kg as a β-antagonist. These are the recommended clinical dosages of almost 10 times those for humans [26]. In these experiments, the drugs were dissolved in 1 mL of physiological saline and were administered by intraperitoneal (i.p.) injection into the rats. I.p. physiological saline (1 mL) was administered to the control animals. The drugs were administered 5 minutes after pentobarbital anesthesia and blood was collected 60 minutes after administration of the drug.

The effects of acupuncture with naloxone were reviewed to determine the reaction mechanism of blood fluidity.

The ZuSanli was stimulated for 60 minutes while injecting i.p. naloxone (5 mg/kg, Sigma Chem. Co., St Louis, MO, USA) into the abdominal cavity every 10 minutes [27,28]. Physiological saline was injected into the abdominal cavity every 10 minutes in the no-naloxone acupuncture stimulus and the control groups.

2.9. Statistical analysis

The statistical significance between the control and the experimental groups was analyzed with analysis of variance, followed by Fisher’s protected least significant difference test. A p value <0.05 was considered statistically significant.

3. Results

3.1. Effect of acupuncture on blood fluidity

3.1.1. The effect of acupuncture stimulation period

To determine the influence of acupuncture stimulus on blood fluidity, we applied acupuncture stimulation for 15 or 60 minutes at 1 Hz, 3–5 V to the ZuSanli acupoint. Acupuncture was stimulated under anesthesia. Blood samples were collected from the untreated control group 50.78 ± 4.96 seconds; from the 15-minute acupuncture stimulation group, 43.42 ± 0.70 seconds; and from the 60-minute acupuncture stimulation group, 44.73 ± 1.03 seconds (Fig. 2). Results showed that the blood flow time shortened significantly in the two groups with stimulation for 15 or 60 minutes. However, there was no significant difference between the two acupuncture stimulus groups.

3.1.2. The effect of acupuncture stimulus frequency

We applied acupuncture stimulation to determine the influence of acupuncture stimulus on blood fluidity for 1 or 100 Hz at 3–5 V for 60 minutes (acupoint ZuSanli). Acupuncture was stimulated under anesthesia. Blood samples were collected from the abdominal vein after acupuncture stimulus. The blood samples were preprocessed with an anticoagulant (heparin sodium). The control group was anesthetized in the same manner as the experimental groups but did not receive stimulation. The blood flow time from the untreated control group was 50.78 ± 4.96 seconds; from the 1-Hz acupuncture stimulation group, 43.52 ± 2.05 seconds; and that of the 100 Hz acupuncture stimulation group was 44.53 ± 0.88 seconds. Results showed that blood flow time shortened significantly in the two groups with stimulation for 1 or 100 Hz. However, there was no significant difference between the two acupuncture stimulus groups (Fig. 3).

3.1.3. The effect of acupuncture stimulation with naloxone administration

We reviewed the effect of acupuncture with naloxone to determine the reaction mechanism of blood fluidity. Acupuncture on the ZuSanli was stimulated for 60 minutes while injecting i.p. naloxone (5 mg/kg) into the abdominal cavity every 10 minutes. Neither acupuncture stimulus nor

### Table 1  Blood properties of each experimental groups (the animals were used in Fig. 2).

<table>
<thead>
<tr>
<th>Time</th>
<th>Body weight (g)</th>
<th>PLT (10^4/μL)</th>
<th>WBC (10^7/μL)</th>
<th>RBC (10^6/μL)</th>
<th>Hct (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (n = 7)</td>
<td>193.2 ± 5.8</td>
<td>63.9 ± 4.5</td>
<td>5.6 ± 1.2</td>
<td>7.8 ± 0.6</td>
<td>32.2 ± 6.1</td>
</tr>
<tr>
<td>ACU 60 min. (n = 7)</td>
<td>186.5 ± 9.3</td>
<td>62.9 ± 8.2</td>
<td>6.2 ± 1.5</td>
<td>7.1 ± 0.4</td>
<td>37.5 ± 7.8</td>
</tr>
<tr>
<td>ACU 15 min. (n = 7)</td>
<td>189.5 ± 7.4</td>
<td>62.7 ± 0.8</td>
<td>5.7 ± 1.6</td>
<td>7.7 ± 0.7</td>
<td>38.5 ± 4.7</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± standard error of mean. PLT:platelet, WBC:white blood cell, RBC:red blood cell, Hct:hematocrit.

### Table 2  Blood properties of each experimental groups (the animals were used in Fig. 3).

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Body weight (g)</th>
<th>PLT (10^4/μL)</th>
<th>WBC (10^7/μL)</th>
<th>RBC (10^6/μL)</th>
<th>Hct (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (n = 7)</td>
<td>175.2 ± 9.8</td>
<td>58.9 ± 5.5</td>
<td>5.4 ± 2.6</td>
<td>4.5 ± 1.6</td>
<td>37.6 ± 2.2</td>
</tr>
<tr>
<td>ACU 1 Hz (n = 7)</td>
<td>179.0 ± 10.4</td>
<td>59.9 ± 8.3</td>
<td>5.0 ± 1.4</td>
<td>4.8 ± 2.3</td>
<td>40.4 ± 3.5</td>
</tr>
<tr>
<td>ACU 100 Hz (n = 7)</td>
<td>175.2 ± 11.0</td>
<td>60.7 ± 5.7</td>
<td>5.2 ± 2.5</td>
<td>5.0 ± 0.5</td>
<td>41.2 ± 4.6</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± standard error of mean. PLT:platelet, WBC:white blood cell, RBC:red blood cell, Hct:hematocrit.
naloxone was given to the control groups. Physiological saline was injected into the abdominal cavity every 10 minutes of the only acupuncture and the control groups.

The whole blood flow time of the control group was 46.91 ± 1.01 seconds, of the acupuncture group was 44.73 ± 1.03 seconds, and of the naloxone inoculation acupuncture group was 44.26 ± 0.83 seconds. Results showed that blood flow time decreased significantly in the ZuSanli-stimulated and the ZuSanli-stimulated plus naloxone groups, although there was no significant difference between these two groups (Fig. 4).

3.1.4. The effect of intraperitoneal administered adrenergic drugs on blood fluidity

We examined the relationship between adrenergic drugs and blood fluidity (Fig. 5). The time interval for blood from the untreated control group was 38.00 ± 5.50 seconds, from the α-agonist-treated group was 48.86 ± 5.50 seconds and from the β-agonist-treated group was 28.05 ± 0.61 seconds. Therefore, the α-agonist significantly increased the time interval and the β-agonist significantly decreased the time interval relative to the control group. In addition, the time interval for the α-antagonist-treated group was 32.44 ± 1.57 seconds, and for the β-antagonist-treated group 78.22 ± 20.63 seconds. Therefore, the α-antagonist significantly decreased the time interval and the β-antagonist significantly increased the time interval relative to the control group.

3.1.5. The effect of acupuncture stimulation and an adrenergic drug on blood fluidity

We researched the effect of acupuncture with an adrenergic drug to determine the reaction mechanism of blood fluidity. The blood flow time from the untreated control group was 44.91 ± 4.75 seconds, from the acupuncture stimulus group was 44.93 ± 0.73 seconds, and from the β-antagonist-treated and acupuncture stimulus group was 54.69 ± 4.00 seconds. Therefore, the increase of blood fluidity by acupuncture was reversed with the β-antagonist. There was no significant difference between the β-antagonist plus acupuncture and the control groups (Fig. 6).

3.1.6. The effect of acupuncture stimulation and an adrenergic drug on platelet aggregation

We examined the degree of platelet aggregation with PA-20 to determine the change of blood fluidity by acupuncture stimulus. The light transmission (Trans%) of PRP produced from the acupuncture stimulated blood showed a decrease when compared with the control (Fig. 7). The light scattering method revealed that large-sized aggregates of the acupuncture stimulated group had decreased significantly as compared with the control. In addition, medium and small-sized aggregates in the stimulated experimental group increased significantly (Fig. 8). The decrease of platelet aggregation ability by acupuncture and in the light transmission and the light scattering method, were reversed with the β-antagonist (Figs. 7 and 8).

3.2. Basic blood characteristics

In blood fluidity experiments, it is important to consider factors which influence blood properties: the number of erythrocytes, leukocytes, platelets and hematocrit. Therefore, in the case of an experiment involving the administration of a chemical to the abdominal cavity, blood properties are measured after chemical administration. The above-mentioned blood properties showed no significant differences in both the experiment and control groups throughout the stages of this study. Rats were assigned to each group at random (Tables 1–5).

4. Discussion

Disorders of the cardiovascular system, such as hypertension, ischemic heart disease and cerebrovascular disorders, are controlled at least in part by blood fluidity. In addition, when humans sustain psychic and physical stress, disorders of the cardiovascular system increase, and the nervous, endocrine and immune systems affect blood viscosity [29–31].

Blood fluidity is controlled by erythrocytes, leukocytes and blood cell platelets. In addition, it is thought that blood fluidity is influenced by plasma proteins, glucose and lipids.

### Table 3: Blood properties of each experimental groups (the animals were used in Fig. 4).

<table>
<thead>
<tr>
<th>Acupoint</th>
<th>Body weight (g)</th>
<th>PLT (10^4/µL)</th>
<th>WBC (10^7/µL)</th>
<th>RBC (10^6/µL)</th>
<th>Hct (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (n = 7)</td>
<td>195.5 ± 6.2</td>
<td>62.3 ± 3.4</td>
<td>4.7 ± 0.8</td>
<td>5.3 ± 0.6</td>
<td>37.1 ± 2.8</td>
</tr>
<tr>
<td>ACU/only (n = 7)</td>
<td>187.8 ± 8.7</td>
<td>66.7 ± 1.6</td>
<td>4.8 ± 0.6</td>
<td>4.6 ± 0.7</td>
<td>36.2 ± 1.5</td>
</tr>
<tr>
<td>ACU/naloxone (n = 7)</td>
<td>193.5 ± 5.4</td>
<td>60.4 ± 5.3</td>
<td>5.2 ± 0.4</td>
<td>4.9 ± 0.4</td>
<td>33.5 ± 3.5</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± standard error of mean. PLT: platelet, WBC: white blood cell, RBC: red blood cell, Hct: hematocrit.

### Table 4: Blood properties of each experimental groups (the animals were used in Fig. 5).

<table>
<thead>
<tr>
<th>Medicine</th>
<th>Body weight (g)</th>
<th>PLT (10^4/µL)</th>
<th>WBC (10^7/µL)</th>
<th>RBC (10^6/µL)</th>
<th>Hct (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (n = 7)</td>
<td>185.0 ± 9.70</td>
<td>58.9 ± 6.55</td>
<td>6.5 ± 1.06</td>
<td>6.9 ± 0.22</td>
<td>35.0 ± 3.13</td>
</tr>
<tr>
<td>α-agonist (n = 7)</td>
<td>183.5 ± 7.43</td>
<td>60.9 ± 4.92</td>
<td>6.4 ± 1.30</td>
<td>6.1 ± 0.44</td>
<td>36.6 ± 2.98</td>
</tr>
<tr>
<td>β-agonist (n = 7)</td>
<td>181.3 ± 6.05</td>
<td>63.6 ± 2.08</td>
<td>5.7 ± 1.42</td>
<td>5.8 ± 0.42</td>
<td>39.6 ± 2.14</td>
</tr>
<tr>
<td>α-antagonist (n = 7)</td>
<td>184.2 ± 7.80</td>
<td>60.7 ± 3.84</td>
<td>5.5 ± 1.66</td>
<td>6.6 ± 0.36</td>
<td>34.9 ± 4.71</td>
</tr>
<tr>
<td>β-antagonist (n = 7)</td>
<td>186.5 ± 10.45</td>
<td>61.0 ± 5.73</td>
<td>6.4 ± 1.17</td>
<td>6.8 ± 0.46</td>
<td>37.1 ± 2.02</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± standard error of mean. PLT: platelet, WBC: white blood cell, RBC: red blood cell, Hct: hematocrit.
in the blood, inflammatory materials and cytokines. An increase of hematocrit or degradation of erythrocyte deformability becomes resistant when blood passes through thin blood vessels, such as blood capillaries [32]. It is known that an increase of leukocyte adhesion or platelet aggregation ability enhances blood viscosity (Poiseuille’s law) [33,34], and reduced blood fluidity increases blood pressure and the risk of thrombosis.

In addition, when the adhesive property of leukocytes moving along the vascular wall increases, blood flow rate near the vascular wall is slower than that in the central area of the blood vessel. Enhancement of the leukocyte adhesive property increases intravascular friction (shear-stress) according to Newton’s law of friction. An increase of shear-stress deteriorates blood fluidity [8,35–39].

In this experiment, the numbers of leukocytes, erythrocytes and platelets and the percent of hematocrit, showed no difference between the control and the experimental groups (Tables 1–5). These results, therefore, suggest that acupuncture stimulus influences platelet aggregation and the blood coagulation systems. Heparin sodium is combined with antithrombin III and inhibits thrombin activity, coagulation factor Xa and Xlla. In other words, heparin sodium does not inhibit agglomeration of platelets directly. MC-FAN blood fluidity observation showed the influence of platelet aggregation ability, erythrocyte deformability and blood cell number. Hematocrit and red blood cell count showed no differences between the dosage and the control groups (Tables 1–5). These results, therefore, suggest that acupuncture stimulus influences platelet aggregation and the blood coagulation systems.

Fig. 2 shows that when a short period of stimulation (15 minutes) was applied to the Zusanli acupoint, blood fluidity was enhanced compared with the control group. These results show that blood fluidity was enhanced after a short time stimulus, suggesting that acupuncture stimulus has an immediate effect, possibly through a nervous system, on blood fluidity.

Fig. 3 shows that when the acupuncture stimulus frequency changed, the blood fluidity was enhanced at both 1 Hz and 100 Hz. This result indicates that blood fluidity is not affected by change of stimulus frequency. It is known that a low-frequency (1–2 Hz) or a high-frequency (>100 Hz) stimulus influences mechanisms other than those of acupuncture analgesia [28]. An operation is enabled only by acupuncture anesthesia if these two mechanisms influence. We think that a decrease of nociception affects blood fluidity. Electric acupuncture of low frequency stimulus (1–5 Hz) secretes arterenol, serotonin and β-endorphin in the central nervous system. It is thought that the secretion of these transmitters has analgesic and sedative effects on the descending pain modulatory system or the endogenic opioid system [28,40,41]. The precedence study shows acupuncture analgesic system of diffuse noxious inhibitory controls (DNIC) participated in acupuncture and moxibustion induced-analgesia through the endogenous opioid system [42]. In addition, spinal segment-related analgesia occurs at high-frequency (>100 Hz) electric acupuncture. This analgesic system produces an analgesic effect in concurrence with the start of the stimulus. It is thought that the gate control theory applies because this system does not compete with naloxone administration [40,41,43,44].

The results of Fig. 2 show that blood fluidity changes with short time electro acupuncture, suggesting the intervention of the nervous system. However, when we consider the fact that blood fluidity was not affected by a difference of stimulus frequency or naloxone administration, it can be surmised that the endogenic opioid system and the spinal segment system do not contribute to blood fluidity. We speculate that acupuncture stimulus changes blood fluidity by the automatic nervous system and axon reflex, and does not influence the opioid system and the spinal segment analgesia system.

Fig. 6 shows that the reaction of blood fluidity enhanced with acupuncture stimulus may disappear with a β-antagonist. In addition, Figs. 7 and 8 show that the decreases of platelet aggregation ability by acupuncture, in the light transmission and the light scattering methods, were reversed with a β-antagonist. These results show that a β-antagonist inhibits a change of blood fluidity, and acupuncture stimulus affects blood platelets, suggesting that the influence on blood fluidity of acupuncture stimulus is a reaction of the sympathetic nervous system.

When a pain occurs from a bruise, distortion and muscle ache, acupuncture treatment desensitizes the pain. A great deal of preliminary research shows that acupuncture inhibits the nerve action of pain. We hypothesize that acupuncture stimulus changes blood fluidity, separately from the cardiovascular system, and a new blood flow improvement system removing pain from a lesion is present.

### References


