FUNDAMENTAL STUDIES ON ELECTRIC STIMULATOR
USED FOR ACUPUNCTURE ANALGESIA

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ABSTRACT

In order to perform safe and effective electric stimulation in acupuncture analgesia or therapy, basic knowledge concerning the electric stimulator is required. If direct current is used, a negative square wave with a pulse duration of 0.5-1.5 msec should be applied to the needle electrode to perform effective stimulation. Negative current is more effective at lower amperage than positive current and the possible corrosion hazard by the positive current can be avoided.

Since February 1979, we have used acupuncture analgesia as a new method for treating various painful conditions in our pain clinic. We have treated more than 438 patients for pain by this Oriental method, especially by electric acupuncture using a Tokki stimulator. We found that acupuncture was effective in 80% of the cases and obtained good results in the treatment of neck distortion, shoulder and low back pain, and pain in elbow and knee joints (Table 1).

As a routine method of stimulation by acupuncture, needles were inserted into a meridian locus, and a low frequency electric stimulation was employed in most of the cases. Thus, it is important to investigate the characteristics of the electric stimulator used for acupuncture stimulation.

Characteristics of electric stimulator and their analysis

Electric stimulators for acupuncture analgesia can be classified into two types: the alternating current type and the direct current type. Some problems concerning their polarity, pulse duration, and possible corrosion hazards will be discussed.

Pulse duration

The relationship between the peak electric current and pulse duration, which is necessary to create appropriate stimulation for acupuncture therapy, was studied. Three study groups were examined. In the first study, pulses of 5 or 80 msec duration was applied to patients at random, and the necessary peak currents were compared. In the second study, pulses of 5- and 80-msec duration was applied alternately, to the same needle inserted the same patient.

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Table 1. Results of acupuncture treatment from January, 1973, to September, 1975, according to the locations of pain. In 80% of the total cases, acupuncture was found to be effective.

<table>
<thead>
<tr>
<th>Location of pain</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
<th>Effective (%)</th>
<th>Ineffective (%)</th>
<th>Unknown (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>41</td>
<td>64</td>
<td>105</td>
<td>75</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>Neck</td>
<td>28</td>
<td>31</td>
<td>59</td>
<td>36</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Shoulder, Arm</td>
<td>25</td>
<td>24</td>
<td>49</td>
<td>80</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Chest</td>
<td>20</td>
<td>22</td>
<td>42</td>
<td>81</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Abdomen</td>
<td>9</td>
<td>4</td>
<td>13</td>
<td>92</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Back, Leg</td>
<td>82</td>
<td>52</td>
<td>134</td>
<td>86</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Whole body</td>
<td>6</td>
<td>4</td>
<td>10</td>
<td>60</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>etc.</td>
<td>13</td>
<td>13</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>224</td>
<td>214</td>
<td>438</td>
<td>30</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

and the necessary peak currents of both pulse durations were compared. In the first and second studies, the necessary peak currents were 1.1–1.5 mA for 5 msec and 1.3–1.5 mA for 80 msec, and there was no statistical difference between them (Table 2).

In the third study, the pulse duration was changed from 0.1 to 5 msec, and the necessary currents were compared. The pulse duration above 1.5 msec did not decrease the peak current and the current increased sharply as the pulse was reduced below 0.5 msec. The relationship between pulse duration and current was extremely similar to the strength-duration curve for nerves or muscles (Fig. 1).

The reason why the pulse duration of 5 and 80 msec did not differ will be discussed from the threshold theory of electric stimulation-excitation relationship and from the actual distortion of current wave form in the tissue.

In order to elicit excitation in the nerves or muscles by electric stimulation, the electric current must be elevated to the threshold level. Therefore, the increase in pulse duration below the threshold stimulation cannot elicit the excitation. The amount of electric current to cause depolarization was supplied within 1–2 msec. This explains the reason why the pulse duration of both 5 and 80 msec required similar peak current to create similar appropriate stimulation to the same needle in a patient.

The second reason is the distortion of the actual current wave form in the tissue. The early portion of the rectangular wave form of the current was distorted to a spike wave and its duration was similar in both 5- and 80-msec pulses (Fig. 2). If the spike portion of the electric current was effective, the pulse duration above 1.5 msec does not contribute to effective stimulation.

It was concluded from the results ob-

Table 2. Peak electric current to produce appropriate stimulation during acupuncture treatment in groups 1 and 2. In both group there was no significant difference in electric current between 5- and 80-msec pulse duration.

<table>
<thead>
<tr>
<th>Pulse duration</th>
<th>No. Cases</th>
<th>Group</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 msec</td>
<td>120</td>
<td>I</td>
<td>1.1 mA ± 0.8 mA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>II</td>
<td>1.5 mA ± 0.7 mA</td>
<td></td>
</tr>
<tr>
<td>80 msec</td>
<td>80</td>
<td>I</td>
<td>1.3 mA ± 0.7 mA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>II</td>
<td>1.5 mA ± 0.7 mA</td>
<td></td>
</tr>
</tbody>
</table>
Fig. 1. Comparison of required electric current which produces similar stimulation when pulse duration was reduced from 5 msec to 0.1 msec.

Fig. 2. Distortion of the actual current wave form in tissue. The early portion of the rectangular wave form was distorted to a spike wave, and its duration is similar in both 5- and 80-msec pulses.
tained in this study that a pulse duration of 0.5~1.5 msec is adequate for electric acupuncture therapy.\(^1\)

**Polarity**

In the direct current type stimulator, it is customary to use negative current to the needle. The effect of polarity on the electric needle stimulation was investigated in 15 patients. A needle was inserted into Kyokei (G.B.-43) of the right foot and the indifferent plate electrode was placed against the sole of the left foot.

A negative and positive square wave current was applied alternately to the needle and the sensibility to electric stimulation of each polarity was compared. The pulse duration was changed to 5, 1, 0.5, 0.2, and 0.1 msec but the frequency was maintained at 50 Hz. The positive current stimulation required more electric current and voltage than the negative current stimulation. The ratio of positive to negative current was 2.7±0.9 for ampereage and 2.6±0.9 for voltage in the range of pulse duration of 5 to 0.1 msec\(^2\) (Fig. 3).

These results observed for needle electrodes resemble the well-known “law of polar excitation” or “Pfüger’s law” measured for transcutaneous plate electrodes in spite of the difference between needle electrodes and plate electrodes.

It was concluded that if the polarity itself does not affect the therapeutic effect, nega-

![Graph](image-url)

**Fig. 3.** Comparison of the required peak current in positive and negative current stimulation to produce similar stimulation with variable pulse duration. Note that positive current stimulation required 2.7 times more current than negative current stimulation.
Corrosion

It has been known that a negative square wave does not corrode the acupuncture needle, but that positive current may corrode and break the needle when positive current is used for an extended period. In this study, factors for electric corrosion of the needle by positive electric current were examined.

Stainless steel needles (0.2 mm in diameter) were inserted into saline solution and the muscle of rabbits, and a positive square wave was applied to the needle from the electronic stimulator. Amperage of 1 to 10 mA, pulse durations of 1 to 10 msec, and frequencies of 50 and 100 Hz were tested, and the time to electric corrosion of the needle was measured. The corrosion time of the needle with positive current was 9.1 hr when a frequency of 50 Hz, a pulse duration of 1 msec, and an average amperage of 1 mA were used, but when a pulse duration of 10 msec and an average amperage of 2.5 mA were used, the corrosion time was shortened to 0.8 hr. When a frequency
of 100 Hz was used the corrosion time was further shortened. In summary the corrosion time in saline was shortened by increasing the amperage, pulse duration, and frequency\(^1\) (Fig. 4).

In the case of rabbit muscle, corrosion occurred in less than 1 hr at the positive current of 1 mA with 1-msec pulse duration, and this was shorter than the case in saline. It was observed with the microscope that the electric current flowed very unevenly in the flesh, and this might be the reason why corrosion occurred more rapidly in rabbit muscle than in saline.

These results suggest that the application of positive electric current to the acupuncture needle should be avoided, unless some protective measures are taken.

REFERENCES

