Electrophysiological Analysis of Warming up Phenomenon in Myotonia

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The after discharges following grip and percussion in myotonia of 4 cases with myotonic dystrophy were evaluated in repetitive percussion or grip, in cold exposure and in warm exposure electromyographically. By repetition, the after discharges reduced markedly. After 2 or 3 trials, after discharges disappeared or became short duration. During local cooling (15°C-20°C), the amplitude and the prolongation in the duration of after discharges were marked, although these enhanced after discharges were reduced by repetition even in cooling. During local warming (40°C-42°C), the after discharges became less marked or disappeared. Both the warming of muscle and the repetitive movements reduced the duration of abnormal after discharges. These effect might be explained on the same mechanism which was the change of the ion transport in muscle membrane, and could be called as warming up phenomenon together. The degree of these after discharges are close related to the degree of myotonic phenomenon. Myotonia is the disorder of primarily the electrical excitabilities, not the contractile properties. So the method of evaluation of after discharges electromyographically is very valuable compared to the measurement of the relaxation process which was used popular in evaluation of myotonia in the past.

Key Words: After discharge, Grip myotonia, Percussion myotonia, Cooling, Warming, Warming up phenomenon.

Myotonia is a phenomenon in which a failure of the muscle to relax takes place immediately after voluntary contraction has ceased and in which regional muscular contraction occurs for a several seconds after percussion on the muscle. It is believed that this phenomenon in the muscular relaxation process is attributable to abnormalities of prolonged after discharges due to disorders in the muscular cell membrane. Its pathophysiology, however, is still incompletely understood. The degree of myotonia has the influence from many physiological factors and it shows fluctuations in some moment. The main reasons of these fluctuations are in the changes of physiological factors like temperature, effect of previous movements etc. In the past many of these factors to be influenced to the myotonia have been reported based on the subjective observation without objective data.

In this paper, we attempt to evaluate the degree of the myotonia in repetitive exercise, in cold exposure and in warm exposure, by recording this abnormal prolonged after discharges using the surface EMG.

MATERIALS AND METHODS

The subjects were four patients with myotonic dystrophy (three males and one female), aged 30, 33, 41 and 42, respectively (the mean age: 36.5). Surface EMG recordings were undertaken in these patients. The surface electrodes were attached on the thenar, the hypothenar, and...
the flexor and extensor of the forearm, and polygrams were recorded. The patients were instructed to grip as strongly as possible for five seconds, which induced grip myotonia. In addition, percussions were given on the thenar of each patient by the tip of a hammer, which induced percussion myotonia. The conditions for the occurrence of after discharges following grip and percussion and their duration were studied in the following states: the forearm and hand were cooled down to the skin temperature of 15°C to 20°C by covering with ice bag; the forearm and hand were heated to the skin temperature of 40°C to 45°C by covering with a hot pack. And the percussion and grip were repeated several times in the settled intervals.

RESULTS

On the surface EMG recordings, prolonged after discharges following grip and percussion were recorded with 30°-33°C skin temperature.

Repeated grips and repeated percussions: prolonged after discharges following grip and percussion recorded on the surface EMG recordings were decreased by repeated grips or repeated percussions in every 20 seconds. After 2 or 3 trials, abnormal after discharges were disappeared or became short duration. This tendency was marked when the grip was repeated (Fig. 1), moderate when the percussion with the tip of a hammer was repeated. When the repetition was tried in more than 5 minutes delay, no decrement was noted.

Effects of cooling and heating: Grip myotonia and percussion myotonia were markedly aggravated after the hand and forearm were cooled down to the skin temperature of 15° to 20°C with ice bag. On the recordings of after discharge, the increase in the amplitudes and the prolongation in the duration were marked (Fig. 2 and Table 1). The after discharges following grip and percussion were reduced by repetition, even when the hand and forearm were cooled (Fig. 3). The after discharges following grip and percussion became less marked or disappeared after the hand and forearm were heated to the skin tem-

Fig. 1. Rate of the duration of successive after discharges following grips to the duration of the after discharge following first grip in repeated grip contraction every 20 seconds.

Fig. 2. Surface EMG recordings of voluntary muscle contractions and their after discharges following maximum grip of hand and forearm muscles by cooling (15°C) and by warming (42°C).
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Table 1. Rate of the duration of after discharges following grip and percussion during cooling to the duration of after discharges before cooling.

<table>
<thead>
<tr>
<th>CASE</th>
<th>GRIP DURING COOLING/ BEFORE COOLING</th>
<th>PERCUSSION DURING COOLING/ BEFORE COOLING</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>1.66</td>
<td>1.61</td>
</tr>
<tr>
<td>#2</td>
<td>3.37</td>
<td>2.23</td>
</tr>
<tr>
<td>#3</td>
<td>5.22</td>
<td>3.06</td>
</tr>
<tr>
<td>#4</td>
<td>2.10</td>
<td>2.03</td>
</tr>
</tbody>
</table>

Temperature of 40°C to 42°C with a hot pack. In the patients, the after discharges were completely disappeared as shown in figure 2. In the patients in whom after discharges were disappeared, muscular discharge patterns were normal during voluntary muscular contraction induced by grip.

DISCUSSION

There are several studies on the effect of cooling the myotonic muscles.7-10 It is said that cold nonspecifically aggravates all types of myotonia, or merely accentuates the paradoxical myotonia.8 In paramyotonia, however, cold induced muscle stiffness is accompanied by cessation of myotonic discharges,9 while myotonia in the recessive type of myotonia congenita or myotonic dystrophy is not aggravated by cooling.7 There is controversy in the reported results. In our study, the after discharges following grips and percussions became marked when the part of the body of the patients with myotonic dystrophy was cooled.

It is known that the amplitude of miniature endplate potential in normal person is increased by cooling.11-13) Ricker et al.14) found that muscle action potential was also increased by cooling of the muscle.15) It has been believed that muscular movements in normal persons are reduced by cooling.16) In myotonic dystrophy, muscular movements are also reduced by cooling, with increased amplitude of muscular action potentials and with abnormal prolonged after discharges. The increase of muscle action potential is supposed to be caused by the effect of cooling directly at the muscle cell membrane, not the effect on the contractile apparatus. The abnormal prolonged after discharges following grips and percussions are also supposed to be the result of hypothermia of the muscular cell membrane. The mechanism, however, is not clearly understood. The transport of ions in the muscular cell membrane is believed to be changed as the result of a decrease in the temperature.

Contrary to the case of cooling, after discharges following grip or percussion are markedly improved by heating of the muscle. Therefore, temperature has completely the opposite effects on myotonia according to its degree. This tendency was marked in the all four patients with myotonic dystrophy who were the subjects of our study. It is interesting finding that even during cooling the repetitive exercise improve the myotonia. The repetitive exercise might warm the muscle membrane as the warming of the muscle does it. The improvement by warming and repetitive movements seems to be the same physiological base, and these might be called warming up phenomenon together.

REFERENCES


