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Electrodiagnosis of Median-to-Ulnar Nerve Anastomosis and Anomalous Innervation of the Intrinsic Hand Muscles

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Communication between the median and ulnar nerves is a common anomaly in the forearm (Martin-Gruber anastomosis, MGA). The knowledge of these anastomoses and the resulting anomalous innervation patterns is of crucial importance to the clinicians and electromyographers in the performance of nerve conduction and electromyographic studies in normal patients and those with peripheral nerve lesions. One hundred forearms (fifty cases) were examined for median-to-ulnar or ulnar-to-median nerve anastomoses using surface electrodes. We found a motor median-to-ulnar nerve anastomosis occurring in 12% of forearms studied. The incidence of innervation of the different intrinsic hand muscles: abductor pollicis brevis (APB) 17%; abductor digiti quinti (ADQ) 17%; first dorsal interosseus (FDI) 92%. In conclusion, the incidence of MGA in our study corresponds well with the results of other authors. No case of motor ulnar-to-median nerve anastomosis in the forearm could be found. Electromyographers and clinicians need to consider the possibility of a MGA when the hand is evaluated for nerve dysfunction. (J Rehab Med Assoc ROC 1997; 25(2): 149 - 154)

Key words: median-to-ulnar nerve anastomosis, surface electrode, intrinsic hand muscles

INTRODUCTION

Martin, in 1763, and Gruber, in 1870, described a communication between the median and ulnar nerves in the forearm that is now known as the Martin-Gruber anastomosis (MGA)11. In such case, some of the intrinsic muscles, either normally innervated by ulnar nerve (such as first dorsal interosseus or abductor digiti quinti) or by median nerve (such as abductor pollicis brevis), are partially (or totally) innervated by the MGA fibers. The incidence of this anastomosis had been reported to vary from 6% to 44%42-43 according to the method of investigation. However, no study of the incidence had been conducted in Chinese population. Communication between the median and ulnar nerves in the forearm provides for variations in the motor innervation of the intrinsic hand muscles, as proved by anatomical and nerve conduction studies12-13. There is a frequent anastomosis between the median and ulnar nerves in the...
proximal forearm, and a rare one in the distal forearm. The clinical importance of this anastomosis is that an isolated ulnar nerve lesion above the connection site may produce an unusual pattern of intrinsic hand muscles paralysis. For example, there may be considerably less finger clawing than expected in spite of complete ulnar nerve lesion at the elbow because of the innervation of a variable number of intrinsic muscles in the hand by the median-to-ulnar communicating fibers. In addition, it produces characteristic changes in the motor conduction study when a MGA occurs in association with the carpal tunnel syndrome (CTS). In the presence of CTS, median nerve stimulation at the elbow elicits a thenar muscle action potential with an initial positive deflection which is not seen on wrist stimulation. Another less common finding is an erroneously near normal motor latency with median nerve stimulation at the elbow but prolongation of the motor latency on wrist stimulation due to median-to-ulnar nerve anastomosis. This may result in a fast-calculated conduction velocity. The aim of the present study is to evaluate the incidence of MGA and the anomalous innervation pattern of intrinsic hand muscles in Chinese population.

MATERIALS AND METHODS

Subjects

Fifty cases aged 19 to 79 years (mean 52 years), selected in colleague and OPD patients were studied for the presence of MGA. Patients who had neurological symptoms or signs or had previous trauma to the upper extremity were excluded from this study. All cases were performed by one investigator using a Nicolet Viking II EMG machine.

Measurements

The compound muscle action potentials (CMAPs) were recorded over abductor pollicis brevis (APB), abductor digiti quinti (ADQ), and first dorsal interosseous (FDI) simultaneously with the surface electrodes. The supramaximal electrical stimulation on the median and ulnar nerves were done alternatively as follows: median nerve at the wrist (Med-W) and at the elbow (Med-E), ulnar nerve at the wrist (Uln-W) and at the elbow (Uln-E) (Fig. 1). The latencies, amplitudes of the CMAP (if present) over APB, ADQ, and FDI muscles were measured through three channels recording. The amplitudes were measured from the baseline to the negative peak of the potential. The presence of a MGA was assumed when one of the following criteria was fulfilled: (1) CMAP over APB higher on elbow than on wrist stimulation of median nerve, (2) presence of CMAP over FDI and/or ADQ on stimulation of the median nerve at elbow but absent at wrist, (3) CMAP over FDI and/or ADQ higher (greater than 120%) on wrist than on elbow stimulation of the ulnar nerve, or (4) presence of CMAP over APB on stimulation of the ulnar nerve at wrist but absent at elbow. The presence of ulnar-to-medial nerve anastomosis was assumed when one of the following criteria was fulfilled: (1) CMAP over APB higher (greater than 120%) on wrist than on elbow stimulation of the median nerve, (2) presence of CMAP over FDI and/or ADQ on stimulation of the median nerve at wrist but absent at elbow, (3) presence of CMAP over APB on stimulation of the ulnar nerve at elbow but absent at wrist, or (4) CMAP over ADQ and/or FDI higher on elbow than on wrist stimulation of the ulnar nerve.
Of the one hundred forearms examined, twelve (12%) were found to have MGA. Table 1 shows in detail the muscles supplied by the anastomosis based on the criteria mentioned above. There were bilateral findings in four cases and unilateral findings also in four. The sex ratio was three females to five males. The MGA innervates primarily muscles which are normally supplied by the ulnar nerve. Among the 12 hands, the incidence of innervation of the different intrinsic hand muscles: abductor pollicis brevis (APB) 17%; abductor digiti quinti (ADQ) 17%; first dorsal interosseus (FDI) 92% (Table 1). In case 4, both APB and FDI were bilaterally innervated, and ADQ was unilateral. In all other cases only the FDI or ADQ were innervated by a MGA. No motor ulnar-to-median nerve anastomosis could be found in the forearm. Also in case 4, bilateral CTS was diagnosed. In his left hand, the APB muscle strength was still good in spite of severe axonal involvement of the median nerve at wrist.

### DISCUSSION

The MGA involves motor axons almost exclusively. This situation could be predicted based on the six basic patterns of MGA observed in the studies of Srinivasan and Rhodes\(^{[12]}\), because the anastomosis in most cases arose from the anterior interosseus nerve which is a pure motor branch of the median nerve. Involvement of sensory axons is unusual and has been reported in only one case by Santoro et al\(^{[13]}\). Thus sensory conduction study was not particularly performed in our study. In contrast, ulnar-to-median nerve anastomosis in the forearm is rare. It has been reported on only three occasions involving motor axons and only once involving sensory axon\(^{[5,14]}\). No case of this type of anastomosis could be found in our study. Willbourn and Lambert\(^{[7]}\) have reported that the MGA innervates the FDI (95%) much more common than ADQ (41%) and APB (14%), as most authors\(^{[15,16]}\) have reported. In our study, we also found that the FDI (92%) was innervated by the communicating branch more common than ADQ (17%) and APB (17%). Therefore, the FDI recording turns to be the most useful procedure to detect the existence of MGA\(^{[17]}\).

In cases of traumatic or entrapment nerve lesions, the functional loss may differ from that one would expect if a MGA is present. The MGA may also produce additional electrophysiologic changes that make interpretation difficult unless the electromyographer is clearly aware of this anomaly. In ulnar nerve lesion proximal to the elbow with a MGA, loss of function in the intrinsic hand muscles will be less than in the classical picture of ulnar nerve lesion and may complicate the clinical examination\(^{[18]}\). Because of the innervation of FDI, and/or ADQ, and/or adductor pollicis muscles by the

### Table 1. Martin-Gruber anastomosis and its intrinsic hand muscles innervation pattern

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Sex</th>
<th>MGA</th>
<th>APB</th>
<th>ADQ</th>
<th>FDI</th>
</tr>
</thead>
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<td>1</td>
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<td>M</td>
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<td>-/-</td>
<td>-/-</td>
<td>+/+</td>
</tr>
<tr>
<td>2</td>
<td>68</td>
<td>M</td>
<td>bilateral</td>
<td>-/-</td>
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<td>+/+</td>
</tr>
<tr>
<td>3</td>
<td>54</td>
<td>F</td>
<td>left</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>65</td>
<td>M</td>
<td>bilateral</td>
<td>+/+</td>
<td>+/-</td>
<td>+/+</td>
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<td>5</td>
<td>29</td>
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<td>+</td>
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<td>+</td>
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<td>70</td>
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<td>bilateral</td>
<td>-</td>
<td>-</td>
<td>+/+</td>
</tr>
</tbody>
</table>

MGA = Martin-Gruber anastomosis
APB = abductor pollicis brevis
ADQ = abductor digiti quinti
FDI = first dorsal interosseus
median-to-ulnar communicating axons, the degree of clinical weakness may be considerably less than anticipated. In the case of CTS in patient with MGA, it produces characteristic changes in motor conduction study. Median nerve stimulation at the elbow evokes a thenar muscle action potential with an initial positive deflection which does not present on wrist stimulation of the nerve. This phenomenon is only seen in patients with coexistence of CTS and MGA. Gutmann noted this change in 25% of median nerves of 63 consecutive patients with bilateral CTS. This finding is clinically important in the diagnosis of mild CTS, especially in the presence of otherwise normal electrophysiologic studies. Another less common finding noted in CTS is an erroneously normal motor latency with median nerve stimulation at the elbow but prolongation of the motor latency on wrist stimulation. The near normal proximal motor latency is due to the communication between the median and ulnar nerves resulting in a fast motor conduction velocity. In our case 4, both hands had CTS and MGA. Moderate to severe degree of axonal involvement was found in the left hand, but its APB muscle strength was still good due to the dual supplies of APB muscle from both original median nerve and MGA fibers.

Spread of stimulus to the neighboring nerve on supramaximal stimulation may easily cause volume-conducted response. To prevent spread of stimulus to the neighboring nerve, therefore, the stimulus intensity should be gradually increased. If one of the criteria for nerve anastomosis was fulfilled on submaximal stimulation, then the similar intensity was used at all of the stimulation sites and the presence of nerve anastomosis could be confirmed. If one of the criteria was matched only on supramaximal stimulation, the spread of stimulus to the neighboring nerve should be suspected and the data should be eliminated. The measures as we described usually provide sufficient control of stimulus spread.

In conclusion, the nerve conduction studies using surface electrodes may confirm the existence of MGA. In patient with ulnar nerve lesion or CTS coexisting with MGA, a variable number of intrinsic hand muscles may not be involved in electrodagnostic findings. The knowledge of MGA and anomalous innervation patterns is essential for the assessment of traumatic or entrapment lesions of the median and ulnar nerves. Clinicians and electromyographers need to consider the possibility of the MGA when the hand is evaluated for nerve dysfunction.

REFERENCES

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正中神經到尺神經神經吻合與手內肌群異常支配之肌電診斷

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正中神經到尺神經之神經吻合(Martin-Gruber anastomosis, MGA)是前臂常見的神經異常支配。其臨床意義在於透過二者之神經吻合，正中神經可支配手部尺神經肌肉群，而不受尺神經病變影響。另外在同時合併有 MGA 及腕部症候群患者、其特別之神經傳導檢查之發現也可提供作診斷之參考。故本研究目的在統計病患發生正中神經到尺神經之神經吻合比例，研究異常支配分佈情形之。以五十位志願受試者一百隻手為測試對象，表面電極貼於魚際肌、小魚際肌與第一背側骨間肌，分別用電刺激肘部與腕部之正中神經與尺神經，以 Nicolet Viking II 肌電圖儀同時記錄複合肌肉動作電位。結果顯示存在正中神經到尺神經之神經吻合有十二隻手(12%)，手內肌群異常支配氣。魚際肌佔 17%、小魚際肌佔 17%、第一背側骨間肌佔 92%，本研究並未發現尺神經到正中神經之神經吻合。我們的結論為正中神經到尺神經之神經吻合在國人約有 12%的發生率，手內肌群異常支配以第一背側骨間肌為主。在臨床上如尺神經病變或腕部症候群的病人做肌電檢查時，建議用本研究所提供的方法過濾“注意有無正中神經到尺神經神經吻合存在，以避免診斷不夠精確所帶來的困擾”(中華復健醫誌 1997; 25(2): 149 - 154)

關鍵詞：正中神經到尺神經神經吻合(median-to-ulnar nerve anastomosis)，表面電極(surface electrode)，手內肌群(intrinsic hand muscles)