Transcranial electrical\textsuperscript{1} or magnetic\textsuperscript{2} stimulation of motor cortex has recently permitted investigation of recovery of central motor pathways. Various neurological diseases affecting the upper motor neuron, including stroke, have been shown to be associated with abnormalities of central motor conduction time (CCT) by using this technique.\textsuperscript{3-9} The value of motor-evoked potentials (MEPs) in predicting functional recovery in stroke patients has been assessed in several studies, most of which have used transcranial electrical stimulation with MEP recordings from hand muscles. Clinical signs usually correlate with electrophysiological findings in those studies.\textsuperscript{10-18} However, there is still controversy about the real prognostic value of MEPs for hemiplegia in acute stroke. While some authors recommend cortical magnetic stimulation as a prognostic indicator in acute stroke,\textsuperscript{12-13-15-17-18} two recent abstracts report no significant predictive value of MEP in the acute stage of hemiplegia.\textsuperscript{19,20}

We assess the value of transcranial magnetic stimulation by using the MEPs recorded from bilateral hand and leg muscles in predicting the prognosis of motor recovery in acute stroke patients.

Subjects and Methods

The study included 14 men and 13 women with a mean age of 62.5 years (range, 29 to 79 years) with acute stroke. Stroke was diagnosed by medical history and computed tomographic (CT) scan of the head. Nineteen patients had infarction and 8 had intracerebral hemorrhage. For the purpose of this study, neurological examination and transcranial magnetic stimulation were performed at the same time in the acute state (in the first week), then 3 and/or 6 months after the event.

Motor function was assessed by Rankin Scale and Barthel Index,\textsuperscript{21,22} which are useful for evaluating the physical abilities and the performance of self-care and are also applicable to the wide variety of stroke patients. The Rankin Scale places a subject in one of five broad categories ranging from grade 1 (no significant disability) to grade 5 (severe disability requiring constant care). The Barthel Index, as a more specific and detailed scale, has 15 items, each of which is graded on four levels (level 1, independent; level 2, independent with assistive device; level 3, requires assistance from another person; and level 4, completely dependent on another person).

The motor function index (MFI) of upper and lower limbs was compared with CCT values recorded from abductor pollicis brevis and tibialis anterior muscles.

For transcranial magnetic stimulation, we used a MagStim 200 stimulator. A circular coil with an outer diameter of 9 cm was placed over the vertex. Recordings were taken from the thenar and tibialis anterior muscles bilaterally using surface electrodes. Medelec Mystro MS-20 was used for electromyographic registrations. Stimulation was performed with maximum intensity while patients maintained a slight contraction of target muscles. Patients with severe paresis who could not maintain a voluntary contraction were asked to contract the healthy extremity to achieve the shortest latency possible. As the facilitation is assumed to occur at a spinal level,\textsuperscript{23} it can be obtained by voluntary contraction of a limb muscle ipsilateral to cortical stimulation.\textsuperscript{4} For each measurement of MEP latency, at least 3 MEPs were recorded, and the one that had the shortest latency was taken. Then 20 consecutive F and M responses were recorded by electrically stimulating the median nerve at the wrist and peroneal nerve at the knee, respectively.

CCT was calculated by the following formula:\textsuperscript{9,20}

\[
\text{CCT} = \frac{F+M-1}{2}
\]

Statistical analyses were performed using Student's t test for evaluating the changes in motor function and CCT values between the initial and the follow-up evaluations. CCT values were compared with the results of normative data provided from our clinical neurophysiology laboratory.
Clinical and Electrophysiological Features of 27 Patients: Initial and Follow-up Examination

<table>
<thead>
<tr>
<th>Patient No./Age, y/Sex</th>
<th>CT Diagnosis</th>
<th>Initial Examination</th>
<th>Follow-up Examination</th>
</tr>
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<tbody>
<tr>
<td></td>
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<td>Muscle Strength*</td>
<td>MEPs</td>
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<tr>
<td></td>
<td></td>
<td>Arm Leg Th TA Rankin Barthel</td>
<td>Arm Leg Th TA Rankin Barthel</td>
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<tr>
<td>1/44/F 5/42/F 3/40/F</td>
<td>L MCA territory infarct</td>
<td>4/5 3/5 N P 3 37</td>
<td>5/5 5/5 N N 2 17</td>
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<tr>
<td>2/40/F 7/60/M 8/61/M</td>
<td>R Carotid artery territory infarct</td>
<td>4/5 4/5 N N 1 15</td>
<td>Nf Nf Nf Nf Nf Nf</td>
</tr>
<tr>
<td>3/40/F 10/75/M 9/59/M</td>
<td>L Thalamic hemorrhage</td>
<td>4/5 4/5 N N 2 16</td>
<td>5/5 5/5 N N 1 15</td>
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<tr>
<td>4/42/F 5/74/F 6/55/M</td>
<td>R MCA territory infarct</td>
<td>4/5 2/5 N A 2 24</td>
<td>5/5 5/5 N P 1 15</td>
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<tr>
<td>5/74/F 7/60/M 6/55/M</td>
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<td>4/5 4/5 N P 3 26</td>
<td>Nf Nf Nf Nf Nf Nf</td>
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<tr>
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<td>Nf Nf Nf Nf Nf Nf</td>
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<tr>
<td>8/61/M 9/59/M 10/75/M</td>
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<td>4/5 4/5 P N 4 39</td>
<td>Nf Nf Nf Nf Nf Nf</td>
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<tr>
<td>9/59/M 11/50/M 12/69/M</td>
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<td>1/5 2/5 P A 5 52</td>
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<tr>
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<tr>
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<td>3/5 4/5 A N 3 24</td>
<td>5/5 5/5 P N 1 15</td>
</tr>
<tr>
<td>19/80/F 20/59/F 21/66/M</td>
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<tr>
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<td></td>
<td>R MCA territory infarct</td>
<td>3/5 2/5 A A 5 44</td>
<td>3/5 4/5 A N 2 19</td>
</tr>
</tbody>
</table>

CT indicates computed tomography; MEPs, motor-evoked potentials; MFI, motor function index; Th, thenar; TA, tibialis anterior; F, female; M, male; L, left; R, right; MCA, middle cerebral artery; CSO, centrum semiovale; ACA, anterior cerebral artery; N, normal central conduction time; P, prolonged central conduction time; A, absent response; Nf, no follow-up examination; and Ex, died due to stroke within 3 weeks of onset.

*Muscle strength: 0, no strength; 5, full strength.

Results

Patients were categorized in two groups according to the appearance of MEPs recorded from thenar muscles on the affected side: (1) patients without MEPs (non-responsive group) and (2) patients with MEPs (responsive group). All MEPs, whether normal or altered in amplitude and/or latency compared with those of the normal sides, were included in the responsive group. All individual results are shown in the Table.

In the acute stage of stroke, according to thenar recordings no response was obtainable in 17 patients. Their mean MFI was 4.52. Ten patients had normal or prolonged CCT at initial examination despite motor deficit. Their mean MFI was 3.2.

According to tibialis anterior recordings, the nonresponsive group included 17 patients; their mean MFI was 4.27. In the responsive group, there were 10 patients whose mean MFI was 3.4. There was a good correlation between MFI and MEP responses in both groups.

The responsive groups were compared according to the improvement rates in their motor function scores. Functional motor recovery was significant in both groups, and there was no statistical difference (Fig 2).
The comparison of MEP responses in the acute phase of stroke according to the lesion types showed no significant difference in hemorrhage or infarct group. In the follow-up period, functional motor recovery rates did not differ significantly in the two groups (Fig 3).

According to the stroke location as imaged by CT scan, 19 patients had cortical (17 infarcts, 2 hemorrhages) and 8 had subcortical (6 hemorrhages, 2 infarcts) lesions. MEP response was absent in 13 patients with cortical lesions and 4 with subcortical lesions.

**Discussion**

Transcranial magnetic stimulation is a safe and non-invasive procedure that provides objective information about central motor pathways. The purpose of this study was to assess the value of MEP as a predictor of prognosis in acute stroke patients. Our results indicate that in the acute phase of stroke, MEP correlates well with the severity of neurological deficit. This finding is compatible with the other studies made by transcerebral electrical and magnetic stimulation.

Follow-up studies after 3 to 6 months demonstrated that functional motor recovery was not significantly different in the responsive and the nonresponsive groups to transcranial magnetic stimulation. This finding is at variance with the series of Dominkus et al, Abbruzzese et al, and Heald et al because of the differences in patient selection, timing of the first assessment, and methodology. In two of these studies, only arm recordings were taken into consideration. However, we assessed both arm and leg recordings. We believe that arm recordings only do not always reflect the prognosis accurately. Three patients in our series (Nos. 12, 14, and 20) who had leg but not arm responses in the acute stage were improved at follow-up (Table). Nevertheless, our results are in concordance with other recent studies.

According to the lesion types, in the acute phase of stroke, MEP findings were not significantly different in patients with infarcts and hemorrhages. In the follow-up period, the degree of functional motor improvement was not different in the infarct and hemorrhage groups. Depending on stroke location, there were more absent MEPs in patients with cortical lesions. At follow-up, the degree of motor improvement was relatively better in patients with subcortical lesions. Similar findings have been reported by several authors. It is suggested that absent MEP and normal MEPs were seen after both cortical and subcortical strokes, but only subcortical involvement increased latency of cortical MEPs.

In conclusion, MEPs are well correlated with the clinical findings in acute stroke, but the absence of MEP does not necessarily indicate a poor prognosis. Furthermore, contrary to the findings of several studies, our data do not support the use of MEPs in accurately predicting prognosis of motor recovery after acute stroke.

**Acknowledgment**

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References
Prognostic value of transcranial magnetic stimulation in acute stroke.
N Araç, A Sagduyu, S Binai and C Ertekin

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