Prefrontal Dysfunction and Treatment Response in Geriatric Depression

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**Background:** This study investigated the relationship of clinical, neuropsychological, and electrophysiological measures of prefrontal dysfunction with treatment response in elderly patients with major depression.

**Methods:** Forty-nine depressed elderly subjects were studied before and after 6 weeks of adequate antidepressant treatment and compared with 22 psychiatrically normal controls. The psychomotor retardation item of the Hamilton Depression Rating Scale, the initiation/perseveration subscore of the Mattis Dementia Rating Scale, and the latency of the P300 auditory evoked potential were used as indices of prefrontal dysfunction. The intensity of antidepressant drug treatment was classified and monitored for a 6-week period.

**Results:** Abnormal initiation/perseveration score, psychomotor retardation, and long P300 latency predicted 58% of the variance in change of depression scores from baseline to 6 weeks ($F_3=20.1, P<.001$). Depressed patients who remained symptomatic ($n=25$) had more abnormal initiation/perseveration scores and longer P300 latency compared with depressed patients who achieved remission ($n=24$) and control subjects. There were no differences between the last 2 groups. The association between psychomotor retardation, initiation/perseveration scores, P300 latency, and response to antidepressant treatment could not be explained by differences in demographic and clinical characteristics or treatment intensity between remitted and nonremitted depressed patients.

**Conclusions:** Prefrontal dysfunction was associated with poor or delayed antidepressant response in depressed elderly patients. This observation, if confirmed, may aid clinicians in identifying candidates for aggressive somatic therapies and for interventions offering structure of daily activities.

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**Frontostriatal dysfunction occurs in some patients with major depression.** Depression is frequent in disorders of subcortical structures. Disturbances in planning, sequencing, organizing, and abstracting have been reported in late-onset depression and are similar to those occurring in Huntington disease. Memory impairment resembling subcortical dementia often occurs in geriatric depression.

Most functional neuroimaging studies of major depression observed hypoactivity in frontal regions, including the dorsolateral, inferior and medial/anterior cingulate, and the caudate nucleus, but disagreement exists. The prefrontal areas, basal ganglia, and some limbic regions appear to be abnormally activated during depression. Following a word activation task, depressed elderly patients showed greater activation of the left medial prefrontal cortex and less activation of the left putamen than elderly normal controls.

The relationship of prefrontal dysfunction to the course of geriatric depression remains unclear. White matter abnormalities were found to be associated with executive dysfunction, and chronicity of geriatric depression, perhaps by disruption of cortico-striato-pallido-thalamo-cortical pathways (CSPTC). Preliminary findings in depressed adults suggest that long P300 latency is associated with poor response to antidepressants at the end of 5 weeks.

Based on these observations, this study tested the hypothesis that clinical and laboratory evidence of prefrontal dysfunction is associated with poor response to antidepressant treatment. Initiation/perseveration (IP) scores and psychomotor retardation were used as clinical measures of prefrontal dysfunction, because such abnormalities have been observed in patients with frontal lobe lesions and disorders of subcortical structures. Although deficits in IP and psychomotor retardation are not specific to prefrontal dysfunction, functional imaging studies showed that several functions tested by the IP tasks require CSPTC integrity. Performance of a verbal fluency
SUBJECTS AND METHODS

SUBJECTS

The subjects were consecutively recruited elderly (age > 64 years) psychiatric inpatients or outpatients. The controls were elderly community residents recruited through advertisements. Patients were included if they met Research Diagnostic Criteria for unipolar major depressive disorder without psychotic features, a score greater than 16 on the 21-item Hamilton Depression Rating Scale, and no history of other major psychiatric disorders or substance abuse before the onset of depression. The control subjects had no personal or family history of psychiatric illness or substance abuse ascertained by the Schedule for Affective Disorders and Schizophrenia–Lifetime Version and the family history Research Diagnostic Criteria. All subjects and informants signed informed consent.

Subjects were excluded if they had (1) severe or acute medical illness, eg, metastatic cancer; brain tumors; decompensated cardiac, hepatic, or renal failure; or myocardial infarction or stroke within the 3 months preceding the study; (2) neurological disorders, eg, delirium, Parkinson disease, or multiple sclerosis; (3) medical disorders and/or drug exposure that may cause depression, eg, endocrinopathies other than diabetes, lymphoma, or pancreatic cancer or exposure to steroids, β-blockers, methyldopa, clonidine, resequine, tamoxifen, or cimetidine; (4) Mini-Mental State Examination (MMSE) score less than 16 at study enrollment; (5) absence of a reliable informant; or (6) hearing deficits of greater than 55 decibels averaged over frequencies of 1, 2, and 4 kHz. Depressed patients were excluded if the current episode had failed to respond to an ‘adequate’ antidepressant trial prior to entry; ie, 6 weeks at dosages equal to or greater than 50 mg of nortriptyline, 20 mg of fluoxetine, 20 mg of paroxetine, 25 mg of imipramine, 20 mg of desipramine, 20 mg of amitriptyline, 15 mg of doxepin, or 5 mg of sertraline. These criteria resulted in a sample of nonpsychotic depressed elderly patients with a wide range of cognitive impairment and medical morbidity but not a drug-resistant current episode.

MEASURES

The Schedule for Affective Disorders and Schizophrenia–Lifetime Version was administered within 7 days from study enrollment. Depression ratings, cognitive assessments, and P300 assessments were performed after a 3-day psychotropic drug washout; lorazepam was used as needed in 6 of 49 patient subjects. Depressive symptoms were assessed using the Hamilton Depression Rating Scale and the Cornell Scale for Depression in Dementia, a scale validated in elderly patients with a wide range of cognitive impairments. The Newcastle index was used to assess endogenous features of depression.

Cognitive impairment was rated with the MMSE and the Mattis Dementia Rating Scale (DRS). DSM-IV criteria and an MMSE score of less than 24 identified depressed-demented patients. The DRS yields a score for overall impairment as well as a subscore of impairment in IP, conceptualization, construction, memory, and attention. The IP domain consists of word generation, manual sequencing, and graphomotor copying tasks.

Chronic medical burden was assessed with the Cumulative Illness Rating Scale, modified for geriatrics. This scale rates chronic medical burden from 14 organ domains. A total score was computed by adding all domains except the psychiatric domain.

All measures were administered by a research assistant trained by the Clinical Research Center for Geriatric Mood Disorders, White Plains, NY. The raters were blind to the hypotheses and the results of electrophysiological testing.

RESULTS

Seventy-one subjects were studied. Forty-nine were patients with major depression (33 inpatients and 16 outpatients) and 22 were normal controls (Table). There was no significant difference in age or sex between depressed patients and controls (Table). Depressed patients had fewer years of education, greater medical burden, and greater cognitive impairment compared with controls (Table). For this reason, these 3 variables were used as covariates where appropriate.

In depressed subjects, abnormal IP scores and long P300 latency were correlated (partial r = 0.56, P < .001, adjusted for education). The Hamilton Depression Rating Scale psychomotor retardation item was associated with both abnormal IP scores (partial r = 0.47, P < .001, adjusted for DRS – IP) and long P300 latency (partial r = 0.40, P < .005, adjusted for DRS – IP). The P300 amplitude was correlated with psychomotor retardation (partial r = 0.34, P < .04) but not with IP scores (partial r = 0.11, P < .94).

Linear regression showed that a model consisting of IP, psychomotor retardation, and P300 latency predicted a large part (R² = 0.58) of the variance (F₃ = 20.1, P < .001) in Cornell Scale percent change over 6 weeks. The model was significant even when only nortriptyline-treated subjects were included (R² = 0.57, F₃ = 16.2, P < .001). Percent change in Cornell Scale score from baseline was correlated with abnormal IP scores (partial r = 0.40, P < .001, adjusted for DRS – IP), psychomotor retardation (partial r = 0.38, P < .01, adjusted for DRS – IP), and long P300 latency (partial r = 0.74, P < .001, adjusted for DRS – IP), but not P300 amplitude (partial r = 0.11, P < .50). The relationships of IP and P300 latency to Cornell Scale percent change were significant but not independent of other variables.
The P300 evoked response was recorded using a Nicolet CA-2000 system (Nicolet Instruments Corp, Madison, Wis) after breakfast. The signals were 1-kHz standard and 2-kHz target tones (ratio, 4:1) delivered binaurally every 1.1 seconds at 70 decibels sound pressure level above hearing level. The subjects were instructed to press a switch held in the right hand when a target tone was detected. All subjects identified at least 85% of the target tones. Electrodes on the outer canthi of both eyes and above and below the right eye were used to control for eye-movement artifacts. The electroencephalogram was recorded from frontal (Fz), central (Cz), and parietal (Pz) scalp electrode sites, referenced to linked-mastoids, and bandpass-filtered at 0.5 to 30 Hz. Between 50 and 60 artifact-free trials for the target tone were obtained. An average response was constructed for the standard and the target tones and the P300 wave was identified in the target response as a positive-(P2)-negative-(N2)-positive-(P3) complex at the range of 280 to 650 milliseconds, and maximal at the parietal site. Latency was measured at Pz at the intersection of extrapolating lines from the ascending and descending portions of the P300 wave. If 2 P300 peaks were seen within the main peak, the whole peak was scored as a single peak. If the peaks were distinct, the second peak was used to determine latency. Peak amplitude was measured as the highest point of the P300 peak at the Pz electrode site and referred to the prestimulus baseline. The P300 recordings were performed by a trained technician blind to the hypotheses and the results of psychometric testing.

**TREATMENT COURSE**

Depressed subjects were treated according to the following guidelines. (1) Nortriptyline (plasma levels >50 ng/mL) was used in patients without a contraindication to tricyclic antidepressants or history of tricyclic resistance. (2) Nontricyclic agents (bupropion, 150-400 mg; fluoxetine, 20-30 mg; paroxetine, 20-30 mg; phenelzine, 30-45 mg; sertraline, 50-100 mg; tranylcypromine, 30 mg; trazodone, 200-325 mg; or venlafaxine, 150 mg) were used in patients who did not qualify for nortriptyline treatment. During each week, the intensity of treatment was scored according to the Longitudinal Interval Follow-up Evaluation treatment intensity scale modified for geriatric patients. At the end of 6 weeks of treatment, the Cornell Scale was readministered. Remission was defined as a reduction of Cornell Scale score to below 7, because this score best distinguishes depressed from nondepressed elderly patients.

**STATISTICAL ANALYSIS**

Partial correlation was employed to examine the relationship of IP, psychomotor retardation, P300 latency, and Cornell Scale score percent change from baseline in depressed patients, after adjusting for total DRS score minus IP score (DRS − IP) and education. Linear regression analysis examined the variance in Cornell Scale score percent change from baseline and its association to a model consisting of IP, psychomotor retardation, and P300 latency in depressed patients. The Tukey post hoc test was used to investigate differences in distribution of IP scores, psychomotor retardation, and P300 latency among unremitted patients, remitted patients, and controls. The sensitivity and specificity of IP, psychomotor retardation, and P300 latency in identifying remission was studied using linear discriminant function analysis with jackknife classification. Logistic regression examined the ability of the 3 measures in predicting remission in patients following treatment. Significance was 2 tailed. The α level of significance in all instances was below .05.

Unremitted depressed patients had more abnormal IP scores and longer P300 latency than remitted depressed patients and controls, while remitted patients and controls had comparable values (Table, Figure 1, Figure 2, and Figure 3). Unremitted patients had comparable P300 amplitude to remitted patients and controls and greater psychomotor retardation than remitted patients (Table). The differences in IP, psychomotor retardation, and P300 latency between remitted and unremitted patients could not be attributed to demographic and clinical differences, because variables that may have influenced remission were similarly distributed in the 2 groups (Table). Moreover, treatment intensity assessed with the modified treatment intensity scale, was similar in remitted and unremitted patients during each of the 6 weeks of treatment (week 1: t<sub>4</sub> = 1.4, P < .17; week 2: t<sub>4</sub> = 0.49, P < .63; week 3: t<sub>4</sub> = 0.87, P < .38; week 4: t<sub>4</sub> = 0.90, P < .38; week 5: t<sub>4</sub> = 0.59, P < .55; week 6: t<sub>4</sub> = 0.10, P < .92).

Discriminant function analysis showed that 23 of the 24 remitted depressed patients were correctly identified based on pretreatment scores on IP, P300 latency, and psychomotor retardation (cross-validation method: sensitivity, 95.8%; specificity, 65.9%). Logistic regression showed that P300 latency was associated with remission (β = −0.07, SE = 0.02, Wald χ<sup>2</sup><sub>1</sub> = 8.9, P < .003). Increments in P300 latency value of 9.7 milliseconds pre-
dicted a 2-fold increase in the likelihood of nonremission (adjusted odds ratio = 0.93; 95% CI, 0.88-0.97).

**COMMENT**

The principal finding of this study is that abnormal IP scores, psychomotor retardation, and long P300 latency are associated with poor or delayed response to antidepressant treatment. Each of these measures has been associated with prefrontal dysfunction.18-23

To our knowledge, this is the first study to demonstrate a relationship between clinical and electrophysiological indices of prefrontal dysfunction and response of geriatric depression to antidepressant treatment. Our findings are consistent with studies in younger adults suggesting that poor response to antidepressants in depressed patients is associated with hypometabolism of the rostral anterior cingulate pathway,37 long P300 latency,15 and white matter hyperintensities.13,24 Simi-

### Demographic and Clinical Characteristics of Elderly Patients With Major Depression and Control Subjects

<table>
<thead>
<tr>
<th>Patients With Major Depression (n = 49)</th>
<th>All Depressed Patients (n = 49)</th>
<th>Remitted Patients (n = 24)</th>
<th>Unremitted Patients (n = 25)</th>
<th>Control Subjects (n = 22)</th>
<th>Comparison†‡§</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>74.8 (5.6)</td>
<td>74.0 (5.7)</td>
<td>75.3 (5.6)</td>
<td>71.8 (4.7)</td>
<td>(1) t69 = 1.9, P &lt; .06; (2) t69 = 0.91, P &lt; .36</td>
</tr>
<tr>
<td>Sex, M/F</td>
<td>1/2.7</td>
<td>1/3.3</td>
<td>1/2.4</td>
<td>1/1.5</td>
<td>(1) χ² = 0.06, P &lt; .82; (2) χ² = 1.5, P &lt; .21</td>
</tr>
<tr>
<td>Race, No. of subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>46</td>
<td>23</td>
<td>23</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Education, y</td>
<td>12.6 (2.4)</td>
<td>12.9 (2.2)</td>
<td>12.3 (2.5)</td>
<td>14.1 (2.5)</td>
<td>(1) t60 = 2.4, P &lt; .02; (2) t49 = 0.97, P &lt; .33</td>
</tr>
<tr>
<td>Age at depression onset, y</td>
<td>55.7 (21.2)</td>
<td>51.6 (24.1)</td>
<td>60.3 (19.3)</td>
<td>...</td>
<td>(2) t69 = 1.8, P &lt; .09</td>
</tr>
<tr>
<td>Duration of depressive episode, wk</td>
<td>43.3 (33.8)</td>
<td>37.9 (34.5)</td>
<td>48.6 (33.7)</td>
<td>...</td>
<td>(2) t69 = 1.1, P &lt; .29</td>
</tr>
<tr>
<td>No. of prior episodes</td>
<td>3.8 (3.5)</td>
<td>3.7 (3.5)</td>
<td>3.8 (3.6)</td>
<td>...</td>
<td>(2) t69 = 0.1, P &lt; .93</td>
</tr>
<tr>
<td>Hamilton Depression Rating Scale27 score at enrollment</td>
<td>22.5 (5.4)</td>
<td>22.1 (4.7)</td>
<td>22.8 (5.9)</td>
<td>1.4 (1.9)</td>
<td>(2) t69 = 0.45, P &lt; .65</td>
</tr>
<tr>
<td>Psychomotor retardation</td>
<td>0.7 (1.0)</td>
<td>0.3 (0.6)</td>
<td>1.0 (1.1)</td>
<td>0.0 (0.2)</td>
<td>(2) F69 = 7.1, P &lt; .02 (Mattis Dementia Rating Scale33 score minus initiation/perseveration score as covariate)</td>
</tr>
<tr>
<td>Cornell Scale for Depression in Dementia31 score at enrollment</td>
<td>18.6 (5.4)</td>
<td>18.1 (5.4)</td>
<td>18.7 (5.5)</td>
<td>0.9 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Cornell Scale score at 6 wk</td>
<td>11.1 (7.4)</td>
<td>4.7 (1.5)</td>
<td>16.9 (5.5)</td>
<td>1.0 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Mattis Dementia Rating Scale33 score</td>
<td>131.1 (12.2)</td>
<td>135.5 (9.9)</td>
<td>125.1 (14.2)</td>
<td>140.9 (2.5)</td>
<td>(1) F1,66 = 9.3, P &lt; .02 (education as covariate)</td>
</tr>
<tr>
<td>Attention</td>
<td>35.5 (1.6)</td>
<td>35.9 (1.6)</td>
<td>35.3 (1.6)</td>
<td>36.4 (0.6)</td>
<td></td>
</tr>
<tr>
<td>Initiation/perseveration</td>
<td>33.3 (4.8)</td>
<td>35.4 (3.4)</td>
<td>30.7 (5.6)</td>
<td>36.6 (0.7)</td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td>5.7 (0.8)</td>
<td>5.9 (0.6)</td>
<td>5.4 (1.1)</td>
<td>6.0 (0.0)</td>
<td></td>
</tr>
<tr>
<td>Conceptualization</td>
<td>35.4 (4.0)</td>
<td>36.8 (2.2)</td>
<td>33.7 (4.8)</td>
<td>37.3 (2.4)</td>
<td></td>
</tr>
<tr>
<td>Memory</td>
<td>21.3 (4.3)</td>
<td>21.9 (4.8)</td>
<td>20.3 (4.1)</td>
<td>24.4 (0.9)</td>
<td></td>
</tr>
<tr>
<td>Newcastle index32</td>
<td>5.8 (1.8)</td>
<td>5.4 (1.8)</td>
<td>6.1 (1.8)</td>
<td>...</td>
<td>(2) t69 = 1.6, P &lt; .12</td>
</tr>
<tr>
<td>Cumulative Illness Rating Scale34 score</td>
<td>4.9 (3.1)</td>
<td>4.8 (2.4)</td>
<td>5.4 (3.8)</td>
<td>3.3 (2.9)</td>
<td>(1) t60 = 2.4, P &lt; .02; (2) t69 = 0.97, P &lt; .33</td>
</tr>
<tr>
<td>P300 latency, ms</td>
<td>383.1 (44.9)</td>
<td>351.7 (25.3)</td>
<td>410.4 (40.5)</td>
<td>341.6 (28.1)</td>
<td>... §</td>
</tr>
<tr>
<td>P300 amplitude, µV</td>
<td>4.0 (2.4)</td>
<td>4.1 (2.3)</td>
<td>3.9 (2.5)</td>
<td>4.6 (1.7)</td>
<td>... ¶</td>
</tr>
</tbody>
</table>

*Data are presented as mean (SD) unless otherwise indicated. Ellipses indicate not applicable; M, male; and F, female.
†1, Depressives vs controls; 2, remitted vs unremitted patients.
‡Unremitted patients vs remitted patients and control subjects; df = 66, P < .01, Tukey posthoc test.
§Unremitted patients vs remitted patients and control subjects; df = 66, P < .001, Tukey posthoc test.
¶Unremitted patients vs remitted patients and pathway; df = 66, P < .93, Tukey posthoc test.

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remitted recruitment of a wide range of depressed pa-

tients. Although the intensity of treatment was com-

parable in remitted and unremitted patients, differences in
the type of treatment may have confounded our find-
ings. For this reason, a controlled treatment study is
needed.

On a heuristic level, this study provides the back-
ground for pharmacological interventions aimed at neu-
rotransmitter systems that mediate prefrontal circuitry,
including dopamine, acetylcholine, and opiates. Such
drugs may be studied alone or as augmenting agents in
depressed elderly patients with evidence of prefrontal dys-
function.

On a clinical level, if confirmed, our findings would
aid clinicians in identifying elderly depressed patients who
may be resistant or slow responders to antidepressants
and, thus, would be useful in treatment planning. De-
pressed patients with prefrontal dysfunction may re-
quire aggressive pharmacotherapy or electroconvulsive
therapy. Studies may also examine if there is a clinical
advantage to stimulating the prefrontal over other brain

Prefrontal dysfunction may result from various
causes, including cerebrovascular and degenerative dis-
orders. Stroke of the caudate head and the left frontal
pole are the most likely ischemic lesions to cause de-
pression. Approximately 75% of patients with major
depression and silent cerebral infarction have lesions
within the perforating arteries, which supply the basal
ganglia. Patients with late-onset depression and vascu-
lar risk factors have neuropsychological abnormalities sug-

gest a prefrontal dysfunction. Finally, in patients with
Alzheimer disease or frontotemporal dementias, depres-
sion is most likely to occur in those with subcortical at-
rophy. These observations suggest that damage of fron-
tostriatal circuits contributes to the development of
depression.

In this study, the associations among psychomotor
retardation, abnormal IP scores, and P300 latency were
significant but rather weak. An explanation may be that
these measures are not highly specific to prefrontal dys-
function. However, psychomotor retardation, abnormal
IP scores, and long P300 latency jointly predicted 58% of
the variance in treatment response. Therefore, de-
pite the lack of a high level of specificity, these 3 mea-
ures may have identified distinct aspects of prefrontal
dysfunction that collectively are associated with poor treat-
ment response. Neuropsychological, electrophysiologi-
cal, and functional imaging techniques focusing on
specific prefrontal circuits may further clarify the patho-
physiology of antidepressant response.

Abnormal IP scores and P300 latency do not seem
to be influenced by the depressive state. In 137 elderly
patients with major depression studied by our institu-
tion, IP scores during depression were similar to IP scores
obtained after recovery (paired \( t_{130} = 0.23, P < .82 \)). Simi-
larly, baseline P300 latency correlated strongly with P300
latency at recovery (\( r = 0.99, df = 37, P < .001 \)). The sta-

bility of IP and P300 latency suggests that examining these
measures when the subjects were depressed may not have
compromised the value of our findings. Abnormal IP
scores and P300 latency in depressed patients seem to
be signs of permanent brain change associated with a treat-
ment-resistant depression.

This study cannot ascertain whether patients with
prefrontal dysfunction had poor as opposed to slow an-
tidepressant response. The duration of study was shorter
than the time required by some elderly patients to achieve
remission. Longer follow-up will be required for this

The naturalistic treatment design of this study per-
mitted recruitment of a wide range of depressed pa-

tients. Although the intensity of treatment was com-
parable in remitted and unremitted patients, differences in
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therapy. Studies may also examine if there is a clinical
advantage to stimulating the prefrontal over other brain
regions in these patients during treatment with electroconvulsive therapy or with transcranial magnetic stimulation. Moreover, interventions specifically targeting executive deficits, including daily structure and support, may be used to remediate disability resulting from prefrontal dysfunction. Such interventions may interrupt the disability-depression downward spiral and promote recovery of depression.

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