Anosognosia in Patients With Cerebrovascular Lesions
A Study of Causative Factors

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Background and Purpose: Psychological and biological hypotheses have been proposed to explain anosognosia. We correlated the presence of anosognosia with the presence and severity of psychiatric disturbances, neglect, intellectual impairments, and computed tomographic evidence of lesion size, location, and measurements of brain atrophy.

Methods: A series of 80 patients with acute stroke were assessed using a battery of psychiatric and neuropsychological tests and computed tomography.

Results: There were five main findings. First, 27 (28%) of the 96 patients originally screened showed anosognosia. Second, patients with anosognosia had significantly higher frequencies of hemispatial neglect and related phenomena, as well as deficits in recognizing facial emotions and in receptive prosody. Third, depression was equally frequent among patients with and without anosognosia. Fourth, patients with anosognosia had a significantly higher frequency of right hemisphere lesions, primarily involving the temporoparietal junction, thalamus, and basal ganglia. Fifth, patients with anosognosia showed significantly more subcortical brain atrophy, primarily involving the frontal white matter and diencephalic areas.

Conclusions: The present study demonstrates that anosognosia does not "protect" stroke patients from depressive feelings; rather, it represents arousal-attentional disorders after lesions in specific areas of the right hemisphere in nonaphasic patients with preexisting subcortical atrophy. (Stroke 1992;23:1446–1453)

Keywords • anosognosia • depression

Anosognosia is a term used by Babinski1 to refer to patients who did not recognize their hemiplegia. The term was later used to describe the denial of other deficits, such as blindness (Anton's syndrome), hemianopsia, etc.2 Two main hypotheses have been advanced to explain the presence of anosognosia. The psychological hypothesis suggests that anosognosia is the consequence of a defensive mechanism by which patients protect themselves from realizing the full extent of their deficits.3 The biological hypothesis postulates several factors that may underlie the presence of anosognosia, such as lesion location (anosognosia may be more frequent after lesions of the right inferior parietal cortex), neglect (anosognosia may be a manifestation of hemi-inattention), or intellectual deficits (anosognosia may be significantly more frequent among patients with cognitive deficits).4

If the psychological hypothesis is correct, a double dissociation between anosognosia and depression should be expected (i.e., anosognosia should "protect" patients from depressive feelings produced by the newly acquired neurological deficit). On the other hand, if the biological hypothesis is correct, there might be an association between anosognosia and lesion location, neglect, or intellectual impairments.

To examine the mechanism of anosognosia, we studied a series of patients with acute cerebrovascular lesions for the presence of anosognosia and correlated its presence and severity with psychiatric disturbances (depression, anxiety, and apathy), neglect, intellectual impairments, and computed tomographic (CT) evidence of lesion size, location, and measurements of brain atrophy.

The focus of our study was to examine whether anosognosia 1) protects stroke patients from depressive feelings, 2) is significantly associated with neglect and related phenomena, 3) is significantly related to cognitive deficits, 4) is significantly associated with lesion variables such as side, size, and location, and 5) is...
significantly related to either cortical or subcortical brain atrophy.

Subjects and Methods

Patients
Patients included in this study were selected from 96 consecutive admissions to the University of Maryland Hospital, Baltimore, for treatment of acute thromboembolic infarction or intracerebral hemorrhage. Patients with a history of cerebrovascular lesions (n=10) or moderate to severe comprehension deficits on the short form of the Token Test (n=6) were excluded from the study. Patients with nonfluent aphasia, however, who could reliably answer questions with affirmative or negative answers were included.

Neurological Examination
The neurological examination and diagnosis were made using the procedures and criteria established by the Stroke Data Bank of the National Institute of Neurological Disorders and Stroke, Bethesda, Md. All neurological evaluations were done by a neurologist who was blinded to findings on the psychiatric and neuropsychological examinations.

Psychiatric Examination
After giving informed consent, the patients were administered a series of standardized quantitative measures of mood, cognitive function, and physical impairment. We have previously shown that these instruments provide reliable and valid measurements in this stroke population.7-9

The modified Present State Examination (PSE), a structured psychiatric interview that elicits symptoms related to depression and anxiety,10 was administered by a psychiatrist. With the use of symptoms elicited by the PSE, a diagnosis of major depression was made using DSM-III criteria.11 The method for conversion of PSE symptoms to DSM-III diagnostic criteria and their concurrence with Research Diagnostic Criteria was demonstrated in a previous publication.12

We have shown that the use of DSM-III symptom clusters for major and dysthetic (minor) depression makes an important distinction between these two types of depression. Major and minor depression have different associations with lesion location,13 response to the dexamethasone suppression test,14 dementia of depression,15-17 clinical severities,12 and longitudinal course.18

The Hamilton Rating Scale for Depression,19 a 17-item interviewer-rated scale, was used to measure psychological and physiological symptoms of depression. The Hamilton Rating Scale for Anxiety,20 a 14-item interviewer-rated scale, was used to measure the severity of generalized or persistent anxiety.

The Mini-Mental State Examination (MMSE)21 and the Johns Hopkins Functioning Inventory (JHFI)20 were also administered to each patient. The JHFI contains 10 items and evaluates the degree of independence in the activities of daily living. Scores range from 0 to 27, and higher scores indicate greater degrees of impairment. Quantitative assessments of social functioning were made using the Social Ties Checklist (STC), which assesses the presence of available social supports.22

The psychiatric evaluations were carried out by a psychiatrist blinded to the rest of the neurological, neuroradiological, and neuropsychological data.

Neuropsychological Examination
The neuropsychological examination was carried out by a neurologist blinded to the remaining data, using a battery of tests that assessed the following domains.

Neglect and related phenomena. Patients were examined for the presence of extinction on double-simultaneous stimulation in three sensory modalities (auditory, visual, and somatosensory). This testing was done using 10 double-simultaneous stimulations intermixed with 20 single stimulations (10 on each side) in a counterbalanced order. The subject was requested to respond by pointing with one finger to the side(s) stimulated. In the case of hemianoptic patients, the double-simultaneous stimulation was administered within the normal visual hemifield. While some patients had hemisensory deficits, all patients could recognize the unilateral single stimulation. The score was the number of errors on left, right, or bilateral stimulations. Allesthetic responses (i.e., reporting the stimulation on the side contrafactual to the real stimulus) were also scored.

Hemispatial neglect. Hemispatial neglect was assessed by asking the patient to copy a complex figure (a symmetrical figure with 10 lines to the left of the midline and 10 lines to the right) and draw five figures from memory (flower, cube, star, clock, and house). The copy of the complex figure was scored as the total number of lines omitted, and the drawing of figures from memory was scored as the number of figures with omissions on any major part of a lateralized subcomponent (maximum score was 5). Patients with significant motor deficits in their dominant hand were not given this test because figures may not be adequately drawn with the nondominant hand (exclusion of these patients may have biased the results on this test).

Personal neglect. Patients were asked to touch the hand contralateral to the lesion with the hand ipsilateral to the lesion. Scores ranged from 0 (the patient promptly reached for the target) to 3 (no movement toward the target).23

Motor neglect. Patients were asked to close and open both hands 20 times. Patients with moderate to severe motor deficits were not given this test. The maximum score was 20.23

Motor impersistence. Patients were asked to keep their eyes closed. The score was the number of seconds the eyes remained closed. The trial was discontinued after 30 seconds.

Recognition of facial emotion. Patients were shown 20 Eckman and Friesen faces with sad, happy, or angry expressions.24 The patients were asked to identify the emotion in the face, using a multiple-choice answer sheet that included vertically arranged schematic drawings of faces with sad, happy, or angry expressions, by pointing to the correct face.

Receptive aprosody. Patients listened through headphones to 13 different six- or seven-word sentences that were recorded by a female speaker using a happy (five sentences), sad (five sentences), or angry (three sentences) tone of voice. All sentences were simple declarative statements, such as “The lamp is on the table.” The order of the sentences was randomized on the tape.
with 10-second intertrial intervals. The stimulus tape was played on a stereophonic recorder and binaurally delivered (through stereophonic headphones) at a comfortable hearing level. To test for possible auditory deficits, patients were asked to repeat the first phrase. Then, patients were asked to identify the emotional prosody and to ignore the semantic content of the sentence. Patients were provided with a response card that had three vertically arranged line drawings of sad, happy, or angry faces and were asked to point to the appropriate face.

Anosognosia questionnaire. This was constructed using questions identified by other investigators as indicative of anosognosia for motor and visual deficits (see Appendix). Based on the responses obtained on the anosognosia questionnaire, patients were classified into the following arbitrary groups: no anosognosia, the patient’s current disorder (i.e., stroke or stroke-related impairment) was spontaneously reported or mentioned after a general question about the patient’s complaint; mild anosognosia, the patient’s current disorder was reported only after a specific question about the strength of the patient’s limb or the presence of visual field deficits; moderate anosognosia, the patient’s disorder was acknowledged only after its demonstration through routine techniques of neurological examination; and severe anosognosia, there was no acknowledgment of the disorder after asking the patient about specific impairments and demonstrating the existence of either motor or visual field deficits.

Neuroradiological Examination

CT scans were obtained during the first week after the stroke from all patients included in the study and were read blinded to the clinical findings. All CT scans were carried out in a General Electric 9900 CT scanner (Milwaukee, Wis.), and 5-mm-thick slices were obtained parallel to the canthomeatal line.

The damaged area was localized in specific brain regions according to the procedure of Levine and Grek. The anteroposterior location of each lesion was defined as the mean distance of the anterior border of the lesion from the frontal pole, averaged over all slices in which the lesion was visible. This distance was expressed as a percentage of the maximum distance between the anterior and posterior poles on the CT slice in which the lesion was identified. The posterior border of each lesion was calculated using the same methods. Lesion area (expressed as a percentage of the total brain area) was calculated from the ratio of the largest cross-sectional area of the lesion to the area of the brain slice that included the body of the lateral ventricles. We have previously demonstrated the reliability of this procedure and its high correlation with other methods of determining lesion volume.

The measurements of cortical and subcortical atrophy were: frontal horn ratio (area of the frontal horn contralateral to the lesion at the level of the foramen of Monro, divided by the area of the whole brain at the same level, multiplied by 1,000), third ventricle ratio (area of the third ventricle at the level of the pineal gland, divided by the area of the whole brain at the same level, multiplied by 1,000), lateral ventricle ratio (area of the lateral ventricle contralateral to the lesion at the waist level, divided by the area of the whole brain at the same level, multiplied by 100), and four cortical sulci ratio (sum of the widths of the four widest sulci divided by the area of the whole brain at the same level, multiplied by 100). All measurements were made using a digitizing tablet (Bioquant, Houston Instruments, Austin, Tex.) attached to an IBM AT computer.

Statistical Analysis

Statistical analysis was carried out using means and standard deviations, one-way analysis of variance with planned comparisons, and t tests. Frequency distributions were analyzed using contingency tables and x^2 tests. Regressions were calculated using a stepwise procedure. All probability values are two tailed.

Results

TABLE 1. Demographic Data for 80 Stroke Patients

<table>
<thead>
<tr>
<th></th>
<th>No anosognosia (n=53)</th>
<th>Mild anosognosia (n=8)</th>
<th>Moderate anosognosia (n=9)</th>
<th>Severe anosognosia (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>56±11</td>
<td>62±11</td>
<td>69±13</td>
<td>62±11</td>
</tr>
<tr>
<td>Days since stroke</td>
<td>5.7±3.9</td>
<td>7.1±4.9</td>
<td>6.7±4.8</td>
<td>5.6±3.5</td>
</tr>
</tbody>
</table>

Values are mean±SD.

Demographic Findings

Of the 80 patients, eight (10%) showed mild anosognosia, nine (11%) moderate anosognosia, 10 (13%) severe anosognosia, and the remaining 53 (66%) no anosognosia. There were no significant between-group differences in demographic variables such as race, sex, education, alcoholism, and presence of family and personal history of psychiatric disorders (data not shown). Patients were mainly black and from a low socioeconomic class. The patients' ages and the time from the stroke to evaluation for anosognosia are given in Table 1.

Neurological Findings

There were no significant between-group differences in motor or sensory deficits, cerebellar and brain stem signs, or frequency or type of aphasia (data not shown). Patients with anosognosia showed significantly higher frequencies of hemineglect and hemianopsia than patients without anosognosia (Table 2). In the mild anosognosia group, all eight patients with hemiparesis had anosognosia for the motor deficit, while none of the three patients with hemianopsia had anosognosia for the visual field deficit. In the moderate anosognosia group, all nine patients with hemiparesis had anosognosia for the motor deficit, while none of the four patients with hemianopsia had anosognosia for the visual field deficit. Finally, in the severe anosognosia group all eight patients with hemiparesis had anosognosia for the motor deficit, while two of the five patients with visual field deficits (four with hemianopsia and one with cortical blindness) had anosognosia for the visual field deficit. In summary, while all 25 patients with hemiparesis and anosognosia had anosognosia for the motor deficits, only two of the 12 patients with visual field deficits had anosognosia for the visual deficit (x^2=28.5, df=1, p<0.001). While this finding demonstrates that anosognosia for motor deficit is significantly more frequent than anosognosia for visual field deficit, the means of
TABLE 2. Results of Neurological Examination in 80 Stroke Patients

<table>
<thead>
<tr>
<th></th>
<th>No anosognosia</th>
<th>Mild anosognosia</th>
<th>Moderate anosognosia</th>
<th>Severe anosognosia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>No</td>
<td>%</td>
<td>No</td>
</tr>
<tr>
<td>Hemineglect*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>4</td>
<td>2</td>
<td>75</td>
<td>6</td>
</tr>
<tr>
<td>Right</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Visual field deficit†</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left hemianopsia</td>
<td>11</td>
<td>6</td>
<td>38</td>
<td>3</td>
</tr>
<tr>
<td>Right hemianopsia</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cortical blindness</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Side of neurological signs‡</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>45</td>
<td>24</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Right</td>
<td>45</td>
<td>24</td>
<td>88</td>
<td>7</td>
</tr>
<tr>
<td>Bilateral</td>
<td>10</td>
<td>5</td>
<td>12</td>
<td>1</td>
</tr>
</tbody>
</table>

*χ²=17.4, df=3, p=0.0006.
†χ²=22.5, df=3, p=0.0001.
‡χ²=13.0, df=6, p<0.05.

questioning may have favored motor over sensory reporting.

Psychiatric Findings

There were no significant between-group differences in terms of depression or anxiety scores, and the frequency of depression (major and minor) was no less frequent among the patients with anosognosia than among those without (Table 3). The distribution of major, minor, or no depression among the three anosognosia groups, however, was significantly different than a random distribution (χ²=13.9, df=6, p<0.05). This was the result of a significantly higher frequency of minor depression among patients with mild anosognosia compared with the other groups (Table 3).

It may still be argued that patients with anosognosia would have had a more severe depression if it were not for anosognosia. To further examine this issue we matched six patients with anosognosia (one with mild, one with moderate, and four with severe anosognosia) and six patients without anosognosia for lesion side (four pairs with right hemisphere lesions and two pairs with left hemisphere lesions) and location (two pairs with temporo-occipital lesions, one pair with frontal dorsolateral lesions, and three pairs with basal ganglia lesions). The groups were comparable in terms of age (anosognosia group, 62.1±13.8 years; no anosognosia group, 58.5±10.4 years; paired t=0.51, difference not significant) and years of education (8.6±3.2 and 11.9±2.6 years, respectively; paired t=1.9, difference not significant). There were no significant differences between the anosognosia and no anosognosia groups in PSE score (14.8±16.5 and 8.1±10.4, respectively; paired t=0.83, difference not significant). Moreover, three of the six patients with anosognosia were depressed (two had major and one had minor depression) compared with two of the six

TABLE 3. Psychiatric Findings in 80 Stroke Patients

<table>
<thead>
<tr>
<th>Parameter</th>
<th>No anosognosia</th>
<th>Mild anosognosia</th>
<th>Moderate anosognosia</th>
<th>Severe anosognosia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present State Exam</td>
<td>9.7±12.0</td>
<td>12.0±8.7</td>
<td>12.4±14.0</td>
<td>7.3±12.5</td>
</tr>
<tr>
<td>Hamilton Depression</td>
<td>5.1±7.2</td>
<td>8.8±9.9</td>
<td>8.3±9.7</td>
<td>3.3±6.3</td>
</tr>
<tr>
<td>Hamilton Anxiety</td>
<td>5.1±8.5</td>
<td>1.0±1.6</td>
<td>6.0±6.2</td>
<td>3.1±6.8</td>
</tr>
<tr>
<td>Major depression</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%</td>
<td>17</td>
<td>13</td>
<td>22</td>
<td>10</td>
</tr>
<tr>
<td>No.</td>
<td>9</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Minor depression*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%</td>
<td>11</td>
<td>50</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No.</td>
<td>6</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No depression</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%</td>
<td>72</td>
<td>37</td>
<td>78</td>
<td>90</td>
</tr>
<tr>
<td>No.</td>
<td>39</td>
<td>3</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Mini-Mental State Exam†</td>
<td>24.3±5.6</td>
<td>22.3±6.5</td>
<td>16.5±8.6</td>
<td>22.1±7.7</td>
</tr>
<tr>
<td>Johns Hopkins Functioning Inventory‡</td>
<td>5.2±4.6</td>
<td>9.7±6.0</td>
<td>10.2±4.1</td>
<td>8.0±5.8</td>
</tr>
<tr>
<td>Social Ties Checklist</td>
<td>2.9±2.0</td>
<td>5.0±2.0</td>
<td>2.8±1.6</td>
<td>4.0±2.5</td>
</tr>
</tbody>
</table>

Values are mean±SD score unless noted.
*χ²=13.2, df=3, p=0.0042.
†F₃,₇₆=3.50, p<0.02; no anosognosia vs. moderate anosognosia, p<0.002.
‡F₃,₇₆=4.01, p<0.01; no anosognosia vs. mild anosognosia, p<0.02; no anosognosia vs. moderate anosognosia, p<0.007.
patients with no anosognosia (one had major and one had minor depression). Thus, even after controlling for important demographic factors and variables previously shown to be relevant to the production of poststroke depression,16 no support was found for the psychological theory of anosognosia.

On the JHFI, patients with mild or moderate anosognosia showed significantly more impairments than patients with no anosognosia (Table 3). On the MMSE, patients with moderate anosognosia had significantly lower scores than the no anosognosia group (Table 3). Differences in JHFI and MMSE scores were also analyzed using more appropriate nonparametric tests, and the findings remained significant (Kruskal-Wallis \( H=10.56, \ p=0.01 \) and \( H=9.43, \ p=0.02 \), respectively). Finally, no significant between-group differences were observed for scores on the STC.

**Neuropsychological Findings**

Patients with anosognosia (mild, moderate, or severe) showed significantly more severe tactile, visual, and auditory extinction contralateral to the lesion on double-simultaneous stimulation than patients without anosognosia (Table 4). Those with anosognosia also showed a significantly higher frequency of motor impersistence (i.e., they kept their eyes closed for a significantly shorter time) and had significantly more severe personal and hemispatial neglect (Table 4).

On the recognition of facial emotion task, patients with anosognosia performed significantly worse than the no anosognosia group, and similar results were found on the receptive aprosody test (Table 4).

**Neuroradiological Findings**

Of the 80 patients, 66 (83%) had positive CT scans. Among the patients with negative CT findings, six had right hemisphere neurological signs, six had left hemisphere signs, and two had bilateral signs.

The first significant finding was that patients with anosognosia had a higher frequency of right hemisphere lesions (Table 5). Patients with mild or severe anosognosia showed significantly higher frequencies of temporoparietal and thalamic lesions than patients with no or moderate anosognosia (Table 5). On the other hand, patients with moderate anosognosia had a significantly higher frequency of lesions involving the basal ganglia (Table 5). No significant between-group differences were observed for other lesion locations. There were no significant between-group differences in the frequency of motor impersistence contralateral to the lesion on double-simultaneous stimulation than patients without anosognosia (Table 4). Those with anosognosia also showed a significantly higher frequency of auditory extinction contralateral to the lesion on double-simultaneous stimulation than patients without anosognosia (Table 4). Those with anosognosia also showed a significantly higher frequency of motor impersistence (i.e., they kept their eyes closed for a significantly shorter time) and had significantly more severe personal and hemispatial neglect (Table 4).

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The first significant finding was that patients with anosognosia had a higher frequency of right hemisphere lesions (Table 5). Patients with mild or severe anosognosia showed significantly higher frequencies of temporoparietal and thalamic lesions than patients with no or moderate anosognosia (Table 5). On the other hand, patients with moderate anosognosia had a significantly higher frequency of lesions involving the basal ganglia (Table 5). No significant between-group differences were observed for other lesion locations. There were no significant between-group differences in the frequency of motor impersistence contralateral to the lesion on double-simultaneous stimulation than patients without anosognosia (Table 4). Those with anosognosia also showed a significantly higher frequency of auditory extinction contralateral to the lesion on double-simultaneous stimulation than patients without anosognosia (Table 4). Those with anosognosia also showed a significantly higher frequency of motor impersistence (i.e., they kept their eyes closed for a significantly shorter time) and had significantly more severe personal and hemispatial neglect (Table 4).

On the recognition of facial emotion task, patients with anosognosia performed significantly worse than the no anosognosia group, and similar results were found on the receptive aprosody test (Table 4).
the first factor (frontal horn ratio $R^2=0.30$, $F=8.87$, $p<0.01$; third ventricle ratio $R^2=0.28$, $F=7.59$, $p<0.01$; lateral ventricle ratio $R^2=0.22$, $F=4.62$, $p<0.05$). Finally, no significant between-group differences were observed in the distance of the anterior or posterior border of the lesion from the frontal pole (Table 6).

To examine the relative importance of the different factors significantly associated with anosognosia, we carried out a stepwise regression analysis in which anosognosia category (i.e., no, mild, moderate, or severe) was the dependent variable and extinction on double-simultaneous stimulation, hemispatial neglect on drawing, recognition of facial emotion, receptive apraxia, subcortical atrophy, lesion location, and impairments in activities of daily living (JHFI) were the independent variables. Two variables accounted for 57% of the variance: the frontal horn ratio ($R=0.69$, $R^2=0.49$, $F=21.0$, $p<0.01$) and lesion location (right temporoparietal or thalamic) ($R=0.75$, $R^2=0.57$, $F=4.03$, $p<0.05$).

### Discussion

The present study examined the frequency and clinical correlates of anosognosia in a series of patients with acute stroke lesions who were capable of undergoing a verbal interview and showed several important findings. First, patients with anosognosia had a significantly higher frequency of neglect and related disorders, such as extinction on double-simultaneous stimulation, motor impersistence, and allesthesiasia. Patients with anosognosia also had significantly more impairments in the recognition of facial emotions and in the comprehension of emotionally intoned speech. Second, patients with anosognosia showed a significantly higher frequency of right hemisphere lesions, mainly involving the superior temporal and inferior parietal cortex, basal ganglia, and thalamus. Third, patients with anosognosia also showed significantly more bilateral subcortical atrophy, as demonstrated by significantly larger frontal horn, lateral ventricle, and third ventricle ratios. When patients with anosognosia were divided into mild, moderate, and severe anosognosia groups, some significant between-group differences emerged. Patients with moderate anosognosia showed significantly more severe cognitive deficits and a higher frequency of lesions involving the basal ganglia. On the other hand, patients with mild or severe anosognosia had higher frequencies of lesions involving the superior temporal and inferior parietal cortex and the thalamus. Finally, patients with mild anosognosia showed a significantly higher frequency of minor depression.

Before further discussion, some limitations of our study should be addressed. First, because we tried to avoid unreliable evaluations, patients with severe comprehension deficits were excluded. Because anosognosia has been frequently reported among patients with Wernicke’s aphasia, our finding of a significantly higher frequency of right hemisphere lesions among patients with anosognosia may be the result of this selection bias. Second, following Bisiach et al., we classified anosognosia into three categories (mild, moderate, and severe), and this classification may be somewhat arbitrary.

### Table 5. Lesion Location in 66 Stroke Patients With Positive Computed Tomograms

<table>
<thead>
<tr>
<th>Location</th>
<th>No anosognosia (n=41)</th>
<th>Mild anosognosia (n=8)</th>
<th>Moderate anosognosia (n=9)</th>
<th>Severe anosognosia (n=8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemisphere</td>
<td>% No.</td>
<td>% No.</td>
<td>% No.</td>
<td>% No.</td>
</tr>
<tr>
<td>Left*</td>
<td>39 16</td>
<td>0 0</td>
<td>33 3</td>
<td>0 0</td>
</tr>
<tr>
<td>Right†</td>
<td>44 18</td>
<td>88 7</td>
<td>67 6</td>
<td>25 2</td>
</tr>
<tr>
<td>Bilateral</td>
<td>7 3</td>
<td>1 1</td>
<td>11 1</td>
<td>12 1</td>
</tr>
<tr>
<td>Frontal</td>
<td>20 8</td>
<td>12 1</td>
<td>11 1</td>
<td>12 1</td>
</tr>
<tr>
<td>Temporoparietal†</td>
<td>20 8</td>
<td>50 4</td>
<td>78 7</td>
<td>25 2</td>
</tr>
<tr>
<td>Superioparietal</td>
<td>7 3</td>
<td>12 1</td>
<td>78 7</td>
<td>25 2</td>
</tr>
<tr>
<td>Basal ganglia§</td>
<td>37 15</td>
<td>12 1</td>
<td>0 0</td>
<td>25 2</td>
</tr>
<tr>
<td>Thalamus†</td>
<td>5 2</td>
<td>38 3</td>
<td>11 1</td>
<td>38 3</td>
</tr>
<tr>
<td>Occipital</td>
<td>10 4</td>
<td>0 0</td>
<td>11 1</td>
<td>25 2</td>
</tr>
<tr>
<td>Insula</td>
<td>10 4</td>
<td>12 1</td>
<td>22 2</td>
<td>12 1</td>
</tr>
<tr>
<td>Posterior internal capsule</td>
<td>15 6</td>
<td>25 2</td>
<td>11 1</td>
<td>25 2</td>
</tr>
<tr>
<td>Corona radiata</td>
<td>12 5</td>
<td>0 0</td>
<td>11 1</td>
<td>25 2</td>
</tr>
<tr>
<td>Posterior fossa</td>
<td>10 4</td>
<td>0 0</td>
<td>0 0</td>
<td>0 0</td>
</tr>
</tbody>
</table>

* $x^2=4.44, df=3, p=0.035$.
† $x^2=10.3, df=3, p=0.015$.
‡ $x^2=9.51, df=3, p=0.023$.
§ $x^2=8.87, df=3, p=0.031$.

### Table 6. Neuroradiological Findings in 51 Stroke Patients

<table>
<thead>
<tr>
<th>Parameter</th>
<th>No anosognosia (n=33)</th>
<th>Anosognosia (n=18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior border (%)</td>
<td>39.3±14.6</td>
<td>32.2±13.6</td>
</tr>
<tr>
<td>Posterior border (%)</td>
<td>61.6±20.8</td>
<td>63.8±20.5</td>
</tr>
<tr>
<td>Lesion area (%)</td>
<td>5.3±8.10</td>
<td>8.9±8.83</td>
</tr>
<tr>
<td>Frontal horn ratio</td>
<td>14.8±6.7</td>
<td>22.0±8.5</td>
</tr>
<tr>
<td>Third ventricle ratio</td>
<td>7.0±4.1</td>
<td>10.4±5.2</td>
</tr>
<tr>
<td>Lateral ventricle ratio</td>
<td>5.7±2.2</td>
<td>7.7±3.7</td>
</tr>
<tr>
<td>Four cortical sulci ratio</td>
<td>2.5±1.4</td>
<td>2.5±1.4</td>
</tr>
</tbody>
</table>

Values are mean±SD.

* $t=3.33, df=49, p=0.0017$.
† $t=2.49, df=49, p=0.016$.
‡ $t=2.43, df=49, p=0.018$. 

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Frequency of Anosognosia

There are very few studies that have systematically examined the frequency of anosognosia. Cutting25 found anosognosia in 58% of patients with right hemisphere lesions (as determined by neurological examination) compared with 14% of patients with left hemisphere lesions. Bisiach et al26 found a frequency of 33% for moderate or severe anosognosia among patients with right hemisphere lesions. These frequencies are similar to our rate of 34% for all patients (10% mild, 11% moderate, and 13% severe anosognosia). When only patients with positive CT scans were considered, the frequency of anosognosia was 38% (12% mild, 14% moderate, and 12% severe) for all patients and 51% for those with right hemisphere lesions.

In conclusion, anosognosia is a frequent complication of stroke lesions and will be found in about one third of stroke patients who can reliably respond to a verbal interview.

Anosognosia and Depression

Several investigators have suggested that anosognosia is a defense mechanism of the individual confronted with his own deficits, thus avoiding the emergence of depressive symptoms.3 If this hypothesis is correct, we would expect to find no depression among patients with anosognosia. The present study, however, empirically demonstrated similar frequencies and severities of major and minor depression among patients with and without anosognosia. Thus, our data did not demonstrate that anosognosia “protects” stroke patients from depressive feelings.27

Anosognosia and Cognitive Impairments

Anosognosia has also been considered as secondary to memory deficits; anosognosia may be present in patients who cannot “remember” the existence of their newly acquired deficits, and the anosognic phenomenon may constitute a confabulation.24 In support of this hypothesis, our patients with moderate anosognosia accepted the presence of a neurological deficit only after it was demonstrated to them through the neurological examination, but they denied the presence of these deficits immediately afterward. Furthermore, patients with moderate anosognosia showed significantly more severe cognitive deficits than the no anosognosia group. On the other hand, patients with severe anosognosia did not show significantly more cognitive deficits than the no anosognosia group. Thus, cognitive impairments are not necessary to produce anosognosia but may, in some patients, constitute a predisposing or contributing factor. Future studies may examine the role of memory deficits in the production of anosognosia using more specific memory measures.

It has also been suggested that anosognosia may be related to unawareness or inattention to the side of space contralateral to the lesion,2 and our data are consistent with this hypothesis. Patients with anosognosia showed significantly more severe hemispatial neglect, personal neglect, and neglect-related phenomena such as extinction on double-simultaneous stimulation, motor impersistence, and allesthesias than patients without anosognosia. Moreover, we found a significantly higher frequency of lesions of the right hemisphere among patients with anosognosia, which may be related to the importance of the right hemisphere in attentional and arousal mechanisms. Thus, an attentional or representational deficit of the contralateral side of the body may be important for the production of anosognosia. It should be remembered, however, that we have no evidence of a causal connection between neglect and anosognosia, and these may be independent phenomena both associated with right hemisphere lesions.

Anosognosia and Lesion Location

Lesion location is another important factor associated with the presence of anosognosia. The present study demonstrates a relation between right thalamus and right temporoparietal cortical lesions and the existence of anosognosia. This finding supports Nielsen's29 suggestion that anosognosia may be caused by thalamic lesions or isolation of the thalamus from the parietal cortex. Another finding of the present study was the relevance of subcortical lesions in the production of anosognosia because there was a significantly higher frequency of basal ganglia lesions among patients with moderate anosognosia.

Anosognosia and Brain Atrophy

Another important factor associated with anosognosia was the presence of subcortical atrophy. Because it was found on the earliest CT scans taken after the onset of symptoms of stroke (i.e., usually 2–3 days), this bilateral subcortical atrophy probably existed before the stroke lesion. Our anosognosic patients showed significantly more severe subcortical atrophy in the area of the frontal horns and lateral and third ventricles. This finding suggests that disruption of frontal subcortical or diencephalic structures may be important predisposing factors for the production of anosognosia. Stuss and Benson30 proposed that regions of the frontal lobe are involved in self-awareness and monitoring of cognitive function and that anosognosia could be viewed as a deficit in self-monitoring. Goldberg and Barr31 also proposed deficits in internal representation or monitoring of output as possible mechanisms of anosognosia. Thus, the presence of frontal and diencephalic atrophy may be a necessary factor for the production of anosognosia after lesions in a specific area of the right hemisphere and may explain why not every patient with a right temporoparietal or thalamic lesion develops anosognosia.

Acknowledgments

We thank Drs. Lynn Speedie and Kenneth Heilman for providing us with the aprosody tapes and for their helpful comments.

Appendix

Anosognosia Questionnaire

1. Why are you here?
2. What is the matter with you?
3. Is there anything wrong with your arm or leg?
4. Is there anything wrong with your eyesight?
5. Is your limb weak, paralyzed, or numb?
6. How does your limb feel?
If Denial Is Elicited Ask the Following:

a) (arm picked up) What is this?
b) Can you lift it?
c) You clearly have some problem with this?
d) (asked to lift both arms) Can't you see that the two arms are not at the same level?
e) (asked to identify finger movements in and out of the abnormal visual field) Can't you see that you have a problem with your eyesight?

Scoring

0: The disorder is spontaneously reported or mentioned following a general question about the patient's complaints.
1: The disorder is reported only following a specific question about the strength of the patient's limb or about visual problems.
2: The disorder is acknowledged only after its demonstration through routine techniques of neurological examination.
3: No acknowledgment of the disorder.

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