
Recovery in Treated Aphasia in the First Year Post-Stroke

MARTHA TAYLOR SARNO, M.A. AND ERIC LEVITA, PH.D.

SUMMARY During a one year post-stroke period of observation, the recovery trend in treated aphasic patients was characterized by general progression in communication skill. The most notable improvement occurred on a measure of everyday function with changes worthy of note on tasks of auditory comprehension and spontaneous word production. In the first 6 months post-stroke, the greatest gain occurred in aphasic patients classified as Fluent, and the least gain in Global aphasics. On the auditory comprehension task, however, improvement was noted in all aphasics regardless of type. In contrast, during the latter half of the first year post-stroke, Fluent aphasics showed least and Global aphasics the greatest improvement. In spite of their progress, Global aphasic patients remained considerably more impaired than the other groups. That the Global aphasics remained so impaired was expected, but the extent and temporal characteristics of their progress in communicating was unexpected.

Study findings are probably affected by failure to consider the variable of time since onset. For this reason, the primary objective of this study was to explore the influence of time in the recovery course of aphasic patients receiving speech therapy.

Methods

Subjects

We studied 34 aphasic patients referred to the Speech Pathology Service of the Institute of Rehabilitation Medicine between May 1970 and December 1976. Patients selected for study had vascular lesions of the left hemisphere confirmed in most by neuroradiologic studies. One had a CVA due to arteriovenous malformation and another due to a ruptured aneurysm of the left internal carotid artery. All were Caucasian, right-handed adults, native speakers of English with normal hearing thresholds across the speech frequencies.

Patients were excluded from the study if they had a history of alcoholism, pre-existing speech disorder, psychiatric disease, previous CVA, or known TIA, or had already received aphasia therapy. Those with aphasia secondary to head trauma or neoplasm, equivocal handedness, or evidence of right hemisphere pathology were also excluded. Patients who were not

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TABLE I
CHARACTERISTICS OF GROUP
BASED ON MEDIANs FOR EACH GROUP AT
8 WEEKs POST STROKE

<table>
<thead>
<tr>
<th>SEX</th>
<th>AGE</th>
<th>EDUCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RANGE</td>
<td>MEDIAN</td>
</tr>
<tr>
<td></td>
<td>RANGE</td>
<td>MEDIAN</td>
</tr>
<tr>
<td>GLOBAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MALE</td>
<td>8</td>
<td>45-77</td>
</tr>
<tr>
<td>FEMALE</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>FLUENT</td>
<td>(WHERE GLOBAL)</td>
<td></td>
</tr>
<tr>
<td>N = 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MALE</td>
<td>4</td>
<td>29-72</td>
</tr>
<tr>
<td>FEMALE</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>NON FLUENT</td>
<td>(WHERE GLOBAL)</td>
<td></td>
</tr>
<tr>
<td>N = 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MALE</td>
<td>6</td>
<td>31-72</td>
</tr>
<tr>
<td>FEMALE</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>ENTIRE GROUP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MALE</td>
<td>16</td>
<td>29-77</td>
</tr>
<tr>
<td>FEMALE</td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>

alert, attentive, or who otherwise seemed unable to cope with the testing process because of illness, severity of cognitive and/or aphasic deficits, were excluded. The rationales for controlling these variables have been frequently pointed out.13-15, 17

There were 18 males and 16 females with a median age of 58, ranging from 29 to 77 years. Years of education ranged from 8 to 20 with a median of 13. There were no significant differences in age, education, or sex.

Patients were assigned to 3 diagnostic groups according to the classification scheme of Benson,18 Geschwind,19 and Goodglass and Kaplan:20 Fluent (F) (N = 8); Non-Fluent (NF) (N = 12); and Global (G) (N = 14). No patient was classified as having transcortical, isolation, or conduction aphasia.

Table 1 shows the age, sex, and education characteristics of the patients according to aphasia type. In terms of these variables the 3 groups were essentially equivalent. Table 2 shows the percentages of in- or out-patients in each of the 3 time periods of the first post-stroke year.

Type of aphasia was determined by a consensus of clinical impressions combined with an analysis of linguistic deficits obtained on language tests (i.e., relationship of speech proficiency to auditory comprehension). Judgments of fluency were made according to the guidelines elaborated by Goodglass and Kaplan;20 that is, a judgment of speech production during extended conversation and free narrative was the basis for assigning a patient to a Fluent or Non-Fluent group.

Fluency is best rated in terms of the longest occasional uninterrupted string of words produced, and is considered an important and reliable diagnostic criterion.21, 22 Fluency allows grouping aphasic syndromes into Fluent and Non-Fluent.

Fluent Aphasia. Usually associated with a lesion in the vicinity of the posterior portion on the first temporal gyrus of the left hemisphere and is characterized by impaired auditory comprehension of fluently articulated speech. The melody and rate of speech in the fluent aphasic is generally normal in all respects. Word and sound substitutions may be of such magnitude and frequency that the patient's speech is virtually a meaningless jargon. In our Fluent group of 7 patients, at 2 month post-stroke, Overall Scores on the Functional Communication Profile (FCP) which can be used as an index of level of severity, ranged from 21% to 51% (median 43%),

TABLE II
IN AND OUT PATIENT STATUS IN PERCENTAGES

<table>
<thead>
<tr>
<th></th>
<th>3 MONTHS</th>
<th>6 MONTHS</th>
<th>12 MONTHS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IP</td>
<td>OP</td>
<td>IP</td>
</tr>
<tr>
<td>GLOBAL</td>
<td>71</td>
<td>29</td>
<td>43</td>
</tr>
<tr>
<td>NON-FLUENT</td>
<td>50</td>
<td>50</td>
<td>8</td>
</tr>
<tr>
<td>FLUENT</td>
<td>38</td>
<td>62</td>
<td>5</td>
</tr>
<tr>
<td>TOTAL</td>
<td>56</td>
<td>44</td>
<td>24</td>
</tr>
</tbody>
</table>
where 100% would be an estimation of pre-morbid communication function.

**Non- Fluent Aphasia.** Characterized by awkward articulation, limited vocabulary, hesitant, slow speech output, restricted use of grammatical forms and a relative preservation of auditory comprehension. The syndrome is associated with anterior lesions usually involving the third frontal convolution of the left hemisphere. At 2 months post stroke the 12 patients in the Non-Fluent group had Overall FCP scores ranging from 26% to 70% (median 40%). The closeness of the median FCP Overall Score of this group to the Fluent group (40% to 43% respectively) at 8 weeks post stroke placed them both at essentially the same starting point, with respect to severity.

The Severe category, referred to as Global Aphasia, posed some problems of classification. Following the precedent already established by several studies, our criteria for designating patients as Global was made on the basis of the “evenness” of dysfunction across all modalities and the severely limited residual use of any communication mode for everyday oral-aural interactions.23 26 The inclusion of the FCP in the study's strength. The strict subject selection criteria for designating patients as Fluent or Non-Fluent and not Global. The FCP is a rating scale for aphasics which considers 45 everyday communication behaviors. Ratings of each behavior are made on a 9-point scale, based on observations of the patient during an informal conversation. An item is given a rating of eight, or normal, when it is believed that the patient performs the behavior as well as he did pre-morbidly. The rationale, reliability, and validity of this instrument have been elaborated elsewhere.23 26 The inclusion of the FCP in this study is considered of particular importance since it emphasizes the effectiveness of everyday communication.

The NCCEA consists of 20 tests of language performance covering communication modalities designed to yield a quantitative profile of specific deficits associated with brain damage. It has been standardized on large samples of normal and aphasic subjects allowing for interpretations according to percentile ranks derived from aphasic and normal populations. The scoring is quantitative, objective, and requires no clinical inferences.27 28 We used the scores obtained on the NCCEA sub-test of Visual Naming, Word Fluency, Sentence Repetition, and Token Test since they are sensitive indicators of impairment in speech and auditory comprehension. In Visual Naming, the patient is instructed to name various common objects on visual confrontation (i.e., cup, comb). In Word Fluency, the patient is instructed to give as many words as he can within one minute beginning with a specified letter. On the Sentence Repetition test, the patient is required to repeat sentences of increasing length and grammatical complexity. The Token Test consists of 39 verbal commands of increasing complexity which require the patient to manipulate 20 plastic tokens of 2 shapes, 2 sizes, and 5 colors. “Show me a circle” is an example of one of the simplest commands. “Put the white square behind the yellow circle” is one of the more difficult ones. The Token Test has been well studied for its sensitivity and discrimination in the measurement of auditory comprehension.29-31

**Testing Schedule**

Our data are based on the systematic testing of a selected group of aphasic patients according to a rigorous time schedule based on the number of weeks post-stroke. The test battery was administered at 4, 8, 12, 26 and 52 weeks post-stroke with a variation allowed of plus or minus one week. T1 refers to the period from one to 3 months post-stroke, T3-4 refers to the respective subsequent intervals. Although the study concerns time-since-onset in a small number of consecutive referrals of aphasics to a rehabilitation service, we believe that the strict adherence to the testing time table, the rigorous criteria for patient selection, the large pool of consecutive referrals from which the final study patients were selected, and the “purity” of the stroke sample constitute the study's strength. The strict subject selection criteria, particularly when applied to patients hospitalized in a metropolitan area (i.e., native English speaker, Caucasian) and the relatively short stay of patients in rehabilitation centers, limited the patients studied. From a pool of 1,730 consecutive admissions of aphasic patients only 135 were eventually included in this study. Among these, only 34 were available for long term study.

**Therapy Schedule**

The amount of speech therapy each patient received ranged from 3 to 5 sessions weekly as shown in table 3. After 3 months post-stroke the total number of
TABLE III
FREQUENCY OF SPEECH THERAPY IN PERCENTAGES
AT 3, 6, AND 12 MONTHS POST-STROKE

<table>
<thead>
<tr>
<th>SESSIONS PER WEEK</th>
<th>3 MONTHS</th>
<th>6 MONTHS</th>
<th>12 MONTHS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 x</td>
<td>3 x</td>
<td>2 x</td>
</tr>
<tr>
<td></td>
<td>5 x</td>
<td>3 x</td>
<td>2 x</td>
</tr>
<tr>
<td></td>
<td>5 x</td>
<td>3 x</td>
<td>2 x</td>
</tr>
<tr>
<td>GLOBAL</td>
<td>71</td>
<td>22</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>43</td>
<td>21</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>NON-FLUENT</td>
<td>56</td>
<td>25</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>42</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>17</td>
<td>33</td>
</tr>
<tr>
<td>FLUENT</td>
<td>63</td>
<td>37</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>75</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>63</td>
<td>13</td>
</tr>
<tr>
<td>TOTAL</td>
<td>64</td>
<td>27</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>41</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>26</td>
<td>21</td>
</tr>
</tbody>
</table>

patients in the study decreased and, therefore, the percentages in these categories no longer added up to 100.

Speech pathologists administered speech therapy without knowledge of which patients were being studied. The specific therapeutic goals were essentially determined by each speech pathologist and generally followed a stimulation/pedagogical approach.17-22

The focus of this study was on the effects of time in the treated aphasic so this, as well as ethical constraints, precluded untreated controls.

Results

Since our concern was the quality and meaning of whatever changes occur in the treated aphasic patient we avoided the prevalent practice of generalizing from group findings to the individual patient.

In our judgment, quantitative statistical analyses would tend to mask important qualitative aspects of improvement, especially when small numbers of patients differing in diagnostic category provided our base. Therefore, clinical analysis seemed appropriate.

For the sake of completeness and background the results of statistical, i.e., group analyses, are shown in the Appendix. To avoid a possible difference in recovery patterns following ruptured aneurysms or arteriovenous malformations, data analyses were carried out first with, and then without, the 2 patients so diagnosed. No difference was noted and, therefore, they were included in the study. As shown in the Appendix, statistically significant improvement in communication over time was noted only on the FCP. This evidence indicates that functional improvement is associated with treated aphasia. In this context, functional refers to communication in real life. Time Since Onset and Recovery

Findings on the NCCEA derived for all patients over the period from 4 to 52 weeks post-stroke are shown in figure 1. Figure 2 illustrates results obtained on FCP Overall scores in the same time period for the total number of subjects studied and across all diagnostic categories.

Four to 8 Weeks Post-onset (T4-8)

Contrary to expectations, little change was observed in all patient groups during the second month post-stroke. On the Token Test our findings are in general agreement with Lomas and Kertesz12 in that comprehension generally changed most during the acute phase. Some clinical improvement was observed in Word Fluency for 5 of the Non-Fluent and 4 of the Fluent patients, but this was not the case among Global patients. This is at some variance with the findings of Lomas and Kertesz.12

Twelve to 26 Weeks Post-onset (T12-26)

Both the Fluent and Non-Fluent groups made the greatest change on the Token Test (F = 23.5; NF = 28.5) and the smallest change on Sentence Repetition (F = 1.5; NF = 1).

Using percentile ranks derived from a normal population as a basis of comparison on the language tests, the group which performed closest to normal twelve weeks post-stroke was the Non-Fluent. It should be noted, however, that the rank on a normal profile which allowed such a comparison is at the 8th percentile. At 6 months post-stroke, both Fluent and Non-Fluent groups, though different in their profiles of language impairment, showed a similar overall pro-

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imunity to normal. That is, for instance, in the Visual Naming the Non-Fluent group is closest to normal, whereas on Word Fluency the Fluent group is closest to normal. The Non-Fluent group showed the least improvement on FCP Overall Score. The Fluent group made the greatest gain in FCP Overall Score.

Twenty-six to 52 Weeks Post-onset (T_{26-52})

During the 6 to 12 month period (T_{12-26}) the trend toward improvement continued for the whole group on both task oriented (NCCEA sub-tests) and functional (FCP) measures as illustrated in figures 1 and 2. During this period the greatest changes on NCCEA sub-tests were shown by the Global group and the smallest gains were seen in the Fluent group which was the reverse of our findings in the T_{12-26} period.

The outstanding finding during this period was the magnitude of the change on Token Test performance in the Global group (median change 31). At one year post-stroke the least impaired group on NCCEA sub-tests was the Non-Fluent group and, as anticipated, the most impaired patients were the Global. On the FCP the greatest change in the T_{26-52} period was achieved by the Global patients. The smallest gains were made by the Fluent patients.

Four to 52 weeks Post-onset (T_{4-52})

Looking at the all-inclusive period from 4 to 52 weeks (T_{4-52}) the general trend is of improvement in all areas on NCCEA and FCP results across the 11 month period.

Analysis Based on Most and Least Improved Patient Groups

If we consider those who improved most and those who improved least by examining the upper (UP) (N = 6) and Lower (LO) (N = 6) sixths of the total group (N = 34) we find that the UP group consisted of 1 Global, 1 Fluent and 4 non-Fluent patients (2 male and 4 female) and the LO group of 4 Global, and 2 Non-Fluent patients (3 male and 3 female).

In the T_{12-52} period the best and poorest patients improved in all modalities with no single test standing out. However, the most marked difference between the UP and LO groups was on Word Fluency. The UP group obtained median changes of 4.0 and the LO group 2.5 on this task in T_{28-62}.

If we examine functional improvement alone, as measured by FCP ratings, the UP group shows a continuous, consistent, and marked improvement over the entire period. The degree of improvement for the UP and LO groups is in sharp contrast. For all practical purposes the LO group stops improving after 26 weeks.

Discussion

We believe that certain characteristics of our patients favored their improvement. It was a relatively young, well educated group with stable home and work situations. In fact, only 5 unemployed patients were retired. All began intensive speech therapy early in a comprehensive rehabilitation medicine setting. None showed mental deficits severe enough to mitigate against possible improvement. The trend for a longer in-patient stay for Global aphasic patients and the converse finding for Fluent aphasics probably were predictable (table 2).

That these patients were treated for a relatively long period of time attests to their motivation and the staff's expectations for their improvement. Although the frequency of treatment decreased during the year (table 3) these patients represented those who "look as if they will improve."

The primary finding of this study was the persistence of improvement in a selected series of patients observed up to a year post-stroke. This agrees with the
long-term reports of some investigators and personal accounts of aphasic patients.9, 10, 31-35

Moving from the date of onset the extent of recovery became less pronounced for the group. There were, however, clear differences in the recovery rates of individual groups when classified according to type and/or severity. While the use of groups in this study is convenient for summarizing data, such summaries are approximations and may mask true and sometimes dramatic changes in individual patients.

In Global aphasia the greatest improvement was noted in the latter part of the first post-stroke year, a finding which agreed with the Kertesz and McCabe study.11 The gains were particularly notable in auditory comprehension, and although the Word Fluency change was not dramatic it was noticeable. At 6 months post-stroke the Global aphasia patient group did not generate any words on a word association task, but after one year their performance reached the 18th percentile rank (aphasia norms). In functional communication, improvement continued at a similar rate with increases on the order of 8% in each time interval. In spite of their progress, Global patients failed to evolve into other types of aphasia by the end of the year and never exceeded a 40% Overall FCP score.

Although the Non-Fluent aphasics generally improved during the year, their rate of improvement tended to decrease in the last 6 months on language tests while the rate of functional recovery was unchanged.

By contrast, the Fluent patients showed little if any change in the latter part of the year. The greatest amount of change occurred in the 2 to 6 month interval. It is of interest that, functionally, the Fluent patients initially showed the same degree of severity as the Non-Fluent patients.

Contrary to the findings of Lomas and Kertesz12 and Kertesz and McCabe,11 the group which showed the least change from the “presumed point of neurological stabilization” (3 months to one year post-stroke) was the Non-Fluent category which changed from 52% to 63% on Overall FCP Scores, an improvement of 13%, whereas the Fluent group showed change on the FCP in the T12-52 inclusive period from 35% to 60% Overall FCP Score and the Global group improvement from 24% to 40% on the FCP score in this period. While it is true that the Global group had the farthest to go, and the Non-Fluents the least, it is, nevertheless, impressive that the Global patients made substantial improvement during the 12 month period.

By the end of the first year post-stroke the Fluent patients were closest to normal on Visual Naming and Word Fluency, whereas the Non-Fluent patients were closest to normal on Sentence Repetition and Token Test performance. We were impressed with the lack of correspondence between task-oriented performance and functional ratings. This finding supports the view that language tests do not necessarily reflect an individual aphasic patient’s actual use of skills and, as such, are limited instruments for measuring progress. This interpretation may be congruent with the view expressed by Lomas and Kertesz19 that extralinguistic compensatory mechanisms may account for certain aspects of recovery in aphasia.

In those patients who improved most and those who
improved least, the greatest relative difference between the best and poorest patients appeared on the Word Fluency task.

In an earlier study we examined the effects of speech therapy in global aphasic patients randomly assigned to 3 treatment conditions: programmed instruction, non-programmed instruction, and no treatment. The groups were equivalent with respect to age, severity, time in treatment, duration of symptoms, and FCP scores. Language recovery was not affected by either speech therapy approach, and the gains in language performance were the same for all patients whether treated or not. Methodological differences between that study and the present one bear mentioning since the results may be erroneously viewed as conflicting. In fact, we hope that by contrasting the 2 studies we will further emphasize the complexities of conducting research in aphasia recovery and rehabilitation.

The earlier study was concerned with the effectiveness of treatment in global aphasia while this one examines the influence of a specific variable, i.e., time since onset, in treated aphasics of all types. In addition to this difference, the patients studied in the 1970 group were older (mean age 64.47) than the present global group (mean age 60.29). But the most striking difference between the 2 global groups under study is time since onset. The 1970 group ranged from 3 to 144 months post-stroke (mean 34.10 months). This suggests that for a variety of reasons patients who are years post-stroke may not derive specific linguistic improvement from speech therapy.

The 1970 study design dictated that patients receive up to 80 half hour (40 full hour) treatment sessions or cease treatment as soon as a restricted set of terminal behaviors was reached. This meant that the treatment period ranged from 3 to 36 weeks for the total group. We do not know what the results might have been if patients had been treated for longer periods or if time since onset had been controlled. The present study suggests that improvement might have been optimal for all treated patients in the earlier investigation had intervention been considered during the first year post-stroke. The findings of this study, as well as some of our earlier work, suggests that time since onset is a crucial variable in recovery from aphasia.

The relevance of change in a condition which has such a powerful negative effect on the quality of life as aphasia cannot be adequately measured by tests of statistical significance. Statistical significance is appropriate only when comparing treatment methods applied to groups, but meaningless with respect to the importance of even small changes in the individual aphasic patient’s daily life. This is especially true when referring to global aphasia where the difference between total absence of word production and the ability to use even a few words in everyday life can make a substantial difference in the individual’s relationship to the real world. We believe that the failure to take into account an aphasic patient’s communication effectiveness in the everyday world has limited some studies. Our findings concerning improvement in functional communication with aphasia therapy add a dimension which is generally overlooked in the interpretation of findings concerning recovery from aphasia.

Acknowledgment

The authors wish to thank Toni Buonaguro for her assistance in analyzing the data. We also wish to thank Dr. John Sarno, Karen Riedel and Shirley Morganstein for their constructive comments, and Rita Sternberg for typing the manuscript.

References


Appendix

Mann-Whitney U Values Based on Test Results at 12 and 52 Weeks Post-Stroke

<table>
<thead>
<tr>
<th>GROUP</th>
<th>SUBTEST</th>
<th>GLOBAL FLUENT</th>
<th>NON-FLUENT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FCP</td>
<td>11**</td>
<td>3**</td>
</tr>
<tr>
<td></td>
<td>VN</td>
<td>21</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>SRP</td>
<td>19.5</td>
<td>18.5</td>
</tr>
<tr>
<td></td>
<td>WF</td>
<td>23.5</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>TT</td>
<td>27.5</td>
<td>14</td>
</tr>
</tbody>
</table>

*Significant at .05 level, two-tailed
**Significant at .02 level, two-tailed


Massive Doses of Steroids in Cryogenic Cerebral Injury and Edema

RAYMOND A. CLASEN, M.D., SYLVIA PANDOLFI, AND JACLYNN R. CLASEN

SUMMARY Cryogenic lesions were produced in the brains of rhesus monkeys and the accompanying edema measured by quantitative chemical methods. No effect on this type of edema could be demonstrated in animals treated with massive doses of steroids.

USE OF STEROIDS in the management of intracranial neoplasms is well established and it is generally accepted that the favorable clinical response is due to reduction of the accompanying cerebral edema. This observation has led to the use of steroids in other clinical situations in which there is also an accompanying cerebral edema, one of these being the management of acute strokes. The impetus to use steroids in strokes came about in spite of the fact that the pathogenesis of the edema in stroke is not the same as with tumors but on the assumption of a similarity in biologic behavior. The effectiveness of steroids in the management of strokes is controversial and it is not clear from the published experimental data whether or not the edema associated with ischemic infarction can be reduced by steroids. In the present report, an attempt was made to treat the edema associated with cryogenic cerebral lesions in the rhesus monkey by massive doses of steroids.

Review

There are 2 different types of cerebral edema associated with acute strokes in the human. One of these is characterized by the presence of a protein-rich extracellular fluid accumulating within the lesion and in the adjacent white matter. This is the type associated with intracerebral hemorrhage and with ischemic infarction when there is a significant hemorrhagic component. It corresponds to Klatzo's vasogenic edema which is also the type of edema associated with cerebral tumors. The second type is characterized by status spongiosis of the infarcted tissue with evidence of cell necrosis. This is seen in ischemic infarction and is sufficiently different from what Klatzo has described as cytotoxic edema to warrant a separate classification as ischemic brain edema. The various experimental models involving the production of generalized or localized cerebral...
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