Lack of Evolution of the Cerebral Blood Flow During Clinical Recovery of a Stroke

*G. DEMEURISSE, M.D., †M. VERHAS, M.D., *A. CAPON, M.D., AND †J. PATERNOT, PH.D.

SUMMARY Cerebral blood flow and clinical parameters were studied in 30 stroke patients at 15th, 30th, 60th, 90th days after the cerebral insult (Xenon 133 inhalation method). The clinical improvement was not accompanied by a progressive normalization of the CBF at rest.

No relationship was found between the clinical data and the CBF values; either on the affected hemisphere or on the contralateral one.

It is concluded that measurement of the CBF at rest has no predictive value as regards further clinical evolution.

THE RECOVERY OF MOTOR FUNCTION in patients suffering from cerebral infarct takes place mainly during the first two to three months. The mechanisms responsible for this recovery are still ill-known.

Vascular hemiplegia is accompanied by a decrease in the cerebral blood flow (CBF) not only in the infarcted region but also in the whole hemisphere and even, according to some authors, in the other hemisphere. A progressive normalization of the CBF might contribute to clinical recovery. In order to test this hypothesis, a prospective study was performed in a group of stroke patients. Sequential measurements of their CBF at rest were made together with clinical assessments.

Material and Methods

Thirty patients, eleven males and nineteen females with a mean age of 65 (33-86) were studied. They all suffered from a unilateral hemispheric infarct demonstrated by the CT scan. The lesion was located in the left hemisphere in sixteen cases and in the right hemisphere in fourteen.

The clinical evaluation included a neurological examination and quantified measurements of motricity and functional independence.

To assess the motor function, six movements pertaining to the proximal, intermediate, and distal joints of the upper and lower limbs were studied (flexion of the shoulder, extension of the elbow, ungał prehension, flexion of the hip, extension of the knee, dorsiflexion of the foot). The importance of the deficit was expressed as a "motricity index" ranging from 0 to 100 (normality). The functional assessment explored the patient’s independence in walking and for activities of daily living (washing, dressing, feeding). The severity of the handicap was expressed as a "functional index" ranging from 0 to 100 (normality). Measurements of CBF were made according to OBRIST’s method by inhalation of Xenon 133. The detector holding blocks included 32 head detectors (¼" x ¼" Nal Tl scintillation crystals) equipped with cylindrical lead collimators.

To secure optimal reproducibility, the detectors were positioned with a precise relation to the orbitomeatal line and the auditory meatus. The results, corrected for pCO2 according to Maximilian et al. were expressed as Initial Slope Index (ISI) measured between 30 seconds and 1 minute 30 seconds after the beginning of the washout.

Our own normal values were established from a group of 29 normal subjects (mean age: 39 ± 15). In addition to the raw values obtained for each detector, their variability in percent of the hemispheric mean was determined. This knowledge of the normal regional distribution of the flows enabled us to determine in the patients areas of regional decreases in flow (in the course of the first measurement). The criterion for abnormality was 2 SD under the normal relative value for a given detector. (For example if this normal value was 96.6 ± 8.6 percent of the mean hemispheric blood flow, any observed value inferior to 79.4 was considered as a significant regional decrease in flow). Clinical evaluation and measurement of the CBF at rest were carried out on the 15th, 30th, 60th and 90th day after the stroke. During this period, patients underwent rehabilitation treatment including physiotherapy and occupational therapy but received no vasoactive drug. The significance of the results was based on Student’s test; Bravais-Pearson correlation coefficients were also used.

Results

The values of the mean hemispheric flows and their regional distribution in the normals are shown in figure 1. In 28 patients, hypoperfused areas (rCBF) in the affected hemisphere were disclosed. For the whole population, the mean hemispheric flows (mCBF) were lower than normal in the affected hemisphere as well as to a lesser extent in the contralateral hemisphere. None of these rCBF or mCBF values did change significantly during the observation period (fig. 2, fig. 3, table 1). This contrasts with the improvement observed in the motricity and functional indices (table 1).

During the 15th to 90 days period, various correlation coefficients were worked out between the clinical indices (motricity index and functional index) on one

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FIGURE 1. Bilateral CBF resting landscape. Regional deviations from the mean hemispheric values are shown in the circles as 'clock' symbols. The stars indicate the significance of these regional deviations from the hemisphere mean value.

The Initial Slope Index (ISI) was chosen for expressing CBF results because it is independent of the partition coefficient of Xenon (which is unknown in cerebral infarcts) and it is little affected by the extracerebral component, which may be important in case of vascular supply by the external carotid artery.

Our values for ISI in the normals were higher than those of other authors because the index was established between 30 and 90 sec. after the beginning of the washout instead of between 2 and 3 min., owing to

Discussion

The clinical assessment of our patients was established through two indices: a motor scale and a functional scale.

The motricity index explored but a limited aspect of the neurological deficit induced by the infarct, whereas the functional index takes into account other associated disorders (sensitive, neuropsychological, . . .).
CEREBRAL BLOOD FLOW DURING CLINICAL RECOVERY OF STROKE/Demeurisse et al.

TABLE 1  CBF Values (± SD) (ISI) at Rest in the Affected and in the Contralateral Hemisphere. Motricity and Functional Indices (± SD) During the Same Observation Period.

<table>
<thead>
<tr>
<th></th>
<th>15th day</th>
<th>30th day</th>
<th>60th day</th>
<th>90th day</th>
<th>Significance of the difference between 15th and 90th days</th>
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<tbody>
<tr>
<td><strong>mCBF</strong></td>
<td></td>
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<tr>
<td>Affected hemisphere (n = 30)</td>
<td>42 ± 8</td>
<td>43 ± 9</td>
<td>45 ± 8</td>
<td>44 ± 11</td>
<td>NS</td>
</tr>
<tr>
<td>Contralateral hemisphere (n = 30)</td>
<td>44 ± 9</td>
<td>47 ± 8</td>
<td>48 ± 10</td>
<td>48 ± 11</td>
<td>NS</td>
</tr>
<tr>
<td>rCBF</td>
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</tr>
<tr>
<td>Affected hemisphere hypoperfused areas (n = 28)</td>
<td>36 ± 6</td>
<td>36 ± 7</td>
<td>40 ± 10</td>
<td>37 ± 10</td>
<td>NS</td>
</tr>
<tr>
<td>Motricity index (n = 30)</td>
<td>38 ± 32</td>
<td>46 ± 33</td>
<td>53 ± 32</td>
<td>57 ± 30</td>
<td>*</td>
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<tr>
<td>Functional index (n = 30)</td>
<td>48 ± 20</td>
<td>61 ± 20</td>
<td>71 ± 20</td>
<td>75 ± 17</td>
<td>*</td>
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</table>

* *p < 0.01.

The age difference between our control group of normal subjects (mean 39 years) and our patients (mean 65 years) cannot by itself account for the decrease in flow in the unaffected hemisphere. According to Sokoloff the age cannot be assessed with precision (a maximum of 20–25% reduction of radioactivity can be expected). 21 Added to the reduction of flow with age this artefact might account for the reduction in flows in the unaffected hemisphere in our atherosclerotic stroke patients.

An asymmetrical but bilateral reduction of the mCBF was found in patients with a well documented unilateral infarct. The reduction in the contralateral hemisphere although less marked was nevertheless obvious. It has been described by several authors. 9, 12, 13

The age difference between our control group of normal subjects (mean 39 years) and our patients (mean 65 years) cannot by itself account for the decrease in flow in the unaffected hemisphere. According to Sokoloff 22 there is no significant reduction in flow in normal elderly subjects, but according to a recent study by Naritomi et al. 23 advancing age is accompanied by a decrease in flow. Nevertheless this decrease does not exceed 14% between 40 and 65 years. It cannot account for the 26% reduction observed in the unaffected hemisphere of our patients.

On the other hand, the cross-talk artefact 24 is probably responsible for an overestimation of flow in the affected hemisphere ("look-through phenomenon") and an additional reduction of flow measurement in the unaffected hemisphere. It cannot be assessed with precision (a maximum of 20–25% reduction of radioactivity can be expected). 21 Added to the reduction of flow with age this artefact might account for the reduction in flows in the unaffected hemisphere in our atherosclerotic stroke patients.

In our series of patients undeniable clinical improvement between the 15th and the 90th days contrasts with the absence of improvement of the CBF.

A few examples of a relation between clinical state and CBF during the first two weeks after a cerebral vascular accident have been described. 18, 26 Rao and co-workers 26 observed in the most ischemic region in symptomatic hemisphere a CBF increase in patients who made significant clinical improvement during the first two weeks after occurrence of maximum disability. However, a cerebral infarct was not clearly demonstrated in all cases and the population studied could also include TIA or RIND patients. Moreover, each series of CBF measurement didn't concern the same group of patients. For Risberg and co-workers, 18 clinical worsening was accompanied by CBF decrease, but no further improvement was really observed after the stroke in their study. These results 18, 26 are not in contradiction with our study in which the cerebral infarct has always been demonstrated. We purposely started on the 15th day in order to avoid practical difficulties.
which are frequently encountered at the acute stage and the interference of possible cerebral edema. It is possible that the first CBF measurement on day 15 comes too late to detect important CBF variations which could occur soon after the stroke. But early after the onset, CBF measurement should be accompanied by cerebral edema evaluation. This will be the purpose of a further study.

In a study on 180 patients, Heiss et al.27 found a relation between the CBF values and some clinical parameters thus attributing a prognostic interest to the CBF measurements. Their population was not as homogeneous as ours (it concerned TIA as well as completed strokes), only the affected hemisphere was studied (with the intraarterial injection method and the bicompartimental analysis), the injection has been completed strokes), only the affected hemisphere was studied (with the intraarterial injection method and the bicompartimental analysis), the injection has been done on the opposite side in cases of internal carotid artery thrombosis. Besides Heiss’s study was not sequential. The single CBF measurement and the first clinical assessment were performed at any time between the first and eighth week after the vascular insult. Since the major clinical changes take place during this lapse of time,1,4 the date of the first clinical assessment should have been standardized for studying the relation between the CBF measurement and the clinical evolution.

On the contrary our own observations not only show that there is no modification of the CBF between the 15th and the 90th days, but also that no prognostic value can be deduced from the CBF measurements at rest since none of the relations studied between them could occur soon after the stroke. But early after the onset, CBF measurement should be accompanied by cerebral edema evaluation. This will be the purpose of a further study.

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Table 2  mCBF and rCBF (± sd) (ISI) at Rest in the Affected and in the Contralateral Hemisphere According to the Clinical Improvement Importance

<table>
<thead>
<tr>
<th></th>
<th>15th day</th>
<th>30th day</th>
<th>60th day</th>
<th>90th day</th>
<th>Significance of the difference between 15th and 90th days</th>
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<tbody>
<tr>
<td>mCBF affected hemisphere</td>
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</tr>
<tr>
<td>Poor clinical improvement group (n = 15)</td>
<td>41±8</td>
<td>41±7</td>
<td>46±8</td>
<td>45±11</td>
<td>NS</td>
</tr>
<tr>
<td>Good clinical improvement group (n = 15)</td>
<td>43±9</td>
<td>45±10</td>
<td>45±9</td>
<td>43±11</td>
<td>NS</td>
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<tr>
<td>mCBF contralateral hemisphere</td>
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</tr>
<tr>
<td>Poor clinical improvement group (n = 15)</td>
<td>43±9</td>
<td>44±6</td>
<td>48±11</td>
<td>49±11</td>
<td>NS</td>
</tr>
<tr>
<td>Good clinical improvement group (n = 15)</td>
<td>44±10</td>
<td>49±10</td>
<td>48±11</td>
<td>47±10</td>
<td>NS</td>
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<tr>
<td>rCBF affected hemisphere, hypoperfused areas</td>
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<td></td>
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<tr>
<td>Poor clinical improvement group (n = 15)</td>
<td>36±8</td>
<td>34±7</td>
<td>42±10</td>
<td>38±10</td>
<td>NS</td>
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<tr>
<td>Good clinical improvement group (n = 13)</td>
<td>35±6</td>
<td>37±9</td>
<td>38±9</td>
<td>37±12</td>
<td>NS</td>
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Table 3  mCBF and rCBF (± sd) (ISI) at Rest in the Affected and in the Contralateral Hemisphere According to the Final Clinical Status

<table>
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<th></th>
<th>15th day</th>
<th>30th day</th>
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<th>90th day</th>
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<tr>
<td>mCBF affected hemisphere</td>
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<tr>
<td>Poor final clinical status group (n = 15)</td>
<td>41±8</td>
<td>42±11</td>
<td>45±8</td>
<td>44±11</td>
<td>NS</td>
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<tr>
<td>Good final clinical status group (n = 15)</td>
<td>43±8</td>
<td>45±5</td>
<td>45±9</td>
<td>45±11</td>
<td>NS</td>
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<tr>
<td>mCBF contralateral hemisphere</td>
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<tr>
<td>Poor final clinical status group (n = 15)</td>
<td>42±9</td>
<td>44±9</td>
<td>48±11</td>
<td>48±11</td>
<td>NS</td>
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<tr>
<td>Good final clinical status group (n = 15)</td>
<td>46±9</td>
<td>50±6</td>
<td>49±10</td>
<td>48±11</td>
<td>NS</td>
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<tr>
<td>rCBF affected hemisphere, hypoperfused areas</td>
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<td>Poor final clinical status group (n = 15)</td>
<td>35±7</td>
<td>33±9</td>
<td>41±10</td>
<td>37±10</td>
<td>NS</td>
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<tr>
<td>Good final clinical status group (n = 13)</td>
<td>36±6</td>
<td>38±6</td>
<td>40±10</td>
<td>38±12</td>
<td>NS</td>
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</tbody>
</table>

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24. Wyper DI, Cooke MBD: Compensating for hemisphere cross-talk when measuring CBF. In Ingvar DH, Lassen NA. Cerebral Function, Metabolism and Circulation. Munksgaard, Copenhagen, 1977
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