Cognitive impairment and adjustment in patients without neurological deficits after aneurysmal SAH and early operation

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The mortality rate has recently been reduced to only a small percentage of patients selected for early aneurysm surgery. Despite recovery without neurological deficits, however, a diffuse encephalopathy may remain, with emotional and psychological sequelae that will interfere with rehabilitation and social reintegration. The present study evaluates quality of life, degree of cognitive dysfunction, and adjustment of patients with a satisfactory neurological recovery after aneurysm operation in the acute stage following a major subarachnoid hemorrhage (SAH). Of 118 patients with a good neurological recovery, 40 patients were randomly sampled for a cross-sectional study and subjected to a questionnaire relating to their symptoms, a clinical interview, and a comprehensive neuropsychological investigation. The time interval between SAH and assessment varied between 14 months and 7 years, averaging 3.89 years. By means of standardized psychometric testing of intellectual capacity, memory functions, visuo-spatial abilities, perceptual speed and accuracy, and concept formation, degrees of cognitive impairment ranging from slight to severe dysfunction were identified. The results suggest that these disturbances may be permanent. The degree of impairment appeared to correlate with the patients' age. Interview data revealed substantial post-hemorrhagic maladjustment with respect to vitality, social management, self-assertion, emotional control, temperament, mood, and cognitive abilities. These findings were considerably at variance with the symptoms reported. It is stressed that, in the absence of gross neurological deficits, vital information on post-hemorrhage adjustment and impairment may easily be overlooked due to psychological defensive measures. It remains an open question whether post-SAH encephalopathy is enhanced by surgery performed in the acute stage.

KEY WORDS • aneurysm • subarachnoid hemorrhage • cognitive impairment • cerebral malfunction • timing of surgery

ANEURYSMAL subarachnoid hemorrhage (SAH) is one of the most deadly illnesses to prey on humans. In a 35-year-old study of primary SAH from Lund, it was concluded that 60% of all individuals who are affected by this catastrophe will eventually die from the disease, 20% will survive in a more or less disabled state, and only one out of five patients will have the chance to become a functional survivor. Despite the fact that operative mortality and morbidity rates in patients selected for surgery have been progressively reduced to only a small percentage in skilled hands, the overall outcome of the disease remains gloomy. Thus, in a recent series of 251 subjects with an aneurysmal SAH, only 107 patients (42%) recovered without gross neurological deficits; the overall morbidity rate was 19%, and the mortality rate was 39%. Aneurysm surgeons are familiar with the fact that some patients with a good neurological recovery after a major SAH and aneurysm operation demonstrate a diffuse encephalopathy with emotional or psychological disturbances, which may interfere with their capacity for work and social reintegration. Such disturbances after severe head trauma have been quite extensively studied. Consequently, it is known that posttraumatic encephalopathy after severe head trauma often results in adverse effects to the cognitive apparatus, causing memory disorders, spatial disorganization, disturbances in reasoning, abstraction, and concept formation, perception difficulties, or other indications of cognitive impairment.

To our knowledge, no similar study has focused on patients who have made a good neurological recovery after rupture and subsequent operation of an intracra-
nial aneurysm, although some studies have touched on the problem.\textsuperscript{18,21,22} The present study was undertaken to establish the quality of life, to elucidate adaptive patterns in such patients, and to establish the degree and extent of any persistent cognitive impairment found.

Clinical Material and Methods

From a series of 160 patients who were classified preoperatively in neurological Grades I, II, or III of Hunt and Hess,\textsuperscript{11} and who had undergone surgery during the acute stage after SAH,\textsuperscript{13} we randomly selected 45 patients without postoperative neurological deficits (Fig. 1). Five of these patients were excluded: one had died as a result of a neoplasm, one refused to take part in the study, and three declined participation for other reasons. Of the remaining 40 patients, 17 were men and 23 women. The ruptured aneurysm was located on the anterior communicating artery (ACoA) in 15 patients, on the internal carotid artery (ICA) in 13 patients, and on the middle cerebral artery (MCA) in 12 patients. Time elapsing between SAH and assessment varied from 14 months to 7 years.

All patients were sent a questionnaire pertaining to their way of life and post-hemorrhagic adjustment (Table 1). Each patient was then subjected to a comprehensive psychological assessment to determine the quality and functioning of his or her cognitive abilities. Standardized psychometric tests were used to evaluate verbal intellectual capacity,\textsuperscript{8} learning and memory functions,\textsuperscript{2,6,8} visuo-spatial organization,\textsuperscript{9,27} perceptual speed and accuracy,\textsuperscript{10,19} and concept formation.\textsuperscript{3} The psychometric tests used are listed in Table 2. To safeguard against overinclusion, rigorous criteria were applied in the designation of inadequate cognitive functioning. Deviations from expected performance to indicate cognitive dysfunction were set to exceed standards normally used in clinical practice.

Each patient was also interviewed about his or her coping behavior after the hemorrhage, with specific attention being paid to changes in self-management presumably related to the SAH. A semi-structured technique was employed to appraise each patient's energy assets and energy consumption, emotional adjustment and psychological management, self-sustenance, and self-regulation. Each patient's self-observation of cognitive functioning was recorded, along with physical complaints and nonspecific reactions allegedly pertaining to the aneurysmal bleed.

Information on working capacity, initiative, and range and direction of interests and activities was obtained. The utilization of energy supplies, tenacity, perseverance, vitality, and sleep regulation was explored. Experience of emotion-related incontinence or emotional change was recorded. Anxiety, tension, vulnerability, and fluctuations in mood were considered. Changes in social mien, including social withdrawal, diminished self-confidence, restrictions in social control and management, and limitations in behavior resources were explored. Neurotic symptoms, phobias, and compulsive tendencies were evaluated, and self-observed disturbances in cognitive function, memory, attention, endurance, conceptualization, and judgment were considered.

Results

Complaints Reported in Questionnaire

Six individuals reported a slight to moderate reduction of their working capacity. Three patients had re-
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TABLE 1

<table>
<thead>
<tr>
<th>Questionnaire administered to patients in series</th>
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</thead>
<tbody>
<tr>
<td>Occupation before illness: ______________________</td>
</tr>
<tr>
<td>Occupation after illness: ______________________</td>
</tr>
<tr>
<td>Total sick leave (months): ______________________</td>
</tr>
<tr>
<td>Completely recovered: __________________________</td>
</tr>
<tr>
<td>Not returned to previous occupation/activities: __</td>
</tr>
<tr>
<td>Symptoms/complaints (check): ____________________</td>
</tr>
<tr>
<td>permanent slightly reduced capacity: ___________</td>
</tr>
<tr>
<td>permanent moderately reduced capacity: __________</td>
</tr>
<tr>
<td>permanent markedly reduced capacity: ___________</td>
</tr>
<tr>
<td>retirement pension due to the illness: _________</td>
</tr>
<tr>
<td>partial retirement pension due to the illness: ___</td>
</tr>
<tr>
<td>permanent sense of fatigue, lack of initiative, infirmity: ____</td>
</tr>
<tr>
<td>permanent headache which did not exist prior to the illness: __</td>
</tr>
<tr>
<td>intermittent headache which did not exist prior to the illness: __</td>
</tr>
<tr>
<td>memory disturbances: ___________________________</td>
</tr>
<tr>
<td>decreased power of concentration: ______________</td>
</tr>
<tr>
<td>emotional change: ______________________________</td>
</tr>
<tr>
<td>disturbances in relation to near relatives: _____</td>
</tr>
<tr>
<td>sexual disturbances: ___________________________</td>
</tr>
<tr>
<td>divorce: ______________________________________</td>
</tr>
<tr>
<td>Other symptoms/complaints: ______________________</td>
</tr>
</tbody>
</table>

received an early retirement pension as a consequence of the SAH. Thirty-one of the patients considered themselves completely recovered. Nevertheless, 12 of these patients reported one or more symptoms. Six of the most common complaints are listed in Fig. 2. A permanent sense of fatigue and lack of initiative was reported by 12 patients (30%). Seven patients had permanent headache, five had intermittent headache that had not existed prior to the SAH, nine reported a decreased power of concentration, seven complained of memory disturbances, three had experienced emotional changes, and another three complained of decreased libido.

Cognitive Dysfunction (Test Results)

Consistent with the type and extent of cognitive dysfunction, the patients were classified into three diagnostic subgroups, implying significant characteristics and representing consecutive degrees of cognitive disturbances. The results are summarized in Fig. 3 and Table 3.

TABLE 2

Description of tests used to evaluate cognitive impairment

<table>
<thead>
<tr>
<th>Test</th>
<th>Description and Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRB: 1 paired associates</td>
<td>Swedish standard verbal intelligence scale(^a)</td>
</tr>
<tr>
<td>Benton visual retention test (BVR)</td>
<td>a short-term memory test for verbal material: immediate recall (CMI) and retention after 3 hours (CMII)(^a)</td>
</tr>
<tr>
<td>Graham-Kendall memory for designs (MFD)</td>
<td>clinical test for exploration of spatial perceptual organization and memory(^2)</td>
</tr>
<tr>
<td>block design test (BD)</td>
<td>test used to estimate general nonverbal intellectual capacity; also a standard clinical tool for detection of visuo-spatial disorganization(^7)</td>
</tr>
<tr>
<td>Bourdon-Wiersma dot test</td>
<td>test presents a problem of simple elimination in a distractive context; performance is highly dependent on perceptual speed and accuracy and is sensitive to fatigue and lack of perseverance; fluctuations in performance over time (BWV) and errors (BWE) are used to indicate dysfunction(^10)</td>
</tr>
<tr>
<td>trail making test (TMT)</td>
<td>test used to appraise perceptual speed, review, and accuracy; impairment is expressed through substantial time difference between the two parts of the test (TMD) and by the total time used to complete the test (TMS)(^9)</td>
</tr>
<tr>
<td>Wisconsin card-sorting test (WCST)</td>
<td>test permits studies of adaptation to changes in the conditions for a concept-forming process, where patients with brain disorders are known to perform less well due to rigidity and disturbed conceptual abilities(^3)</td>
</tr>
</tbody>
</table>
**No or Mild Cognitive Disturbances.** Only one patient was found to be totally without signs of cognitive impairment. Evidence of slight or insignificant dysfunction was shown by six patients, predominantly in the form of verbal learning and memory difficulties of a short-term or intermediate nature. The distribution of disturbances in relation to age, sex, and aneurysm location is shown in Table 3.

**Moderate Cognitive Disturbances.** Twelve patients (30%) presented signs of moderate disturbances (Table 3). In addition to verbal learning and memory dysfunction, these patients showed disturbed spatial organization and visuo-constructive impairment (six patients had two indications of dysfunction while the other six had three indications). Furthermore, deficits in higher mental processes such as abstraction and concept formation could be discerned in this subgroup.

**Marked Cognitive Disturbances.** The third diagnostic category, those patients with marked cognitive disturbances, comprised 21 patients (53%) with numerous indications of cognitive malfunctioning. Eight patients had four indications, five patients had five, six patients had six, and two patients had seven. Apart from a high proportion of learning and memory difficulties, both verbal and nonverbal, there was much evidence of visuo-spatial disorganization and defective conceptualization (Table 3). Perceptual speed and accuracy were also reduced in most patients. Fluctuations in attention and task orientation were common, as well as a lack of cognitive flexibility. In many of these patients the presence of a general deterioration in intellectual processes was evident.

**Recovery Course and Cognitive Sequelae**

The significance of the time interval between hemorrhage and psychometric assessment as a predictor of restitution of cognitive ability was analyzed. The cognitive function subgroups were equal in this respect. The average time lapse since the aneurysmal SAH was 41 to 42 months in all three groups, despite the wide range of cognitive incapacity. An analysis of 10 patients whose SAH occurred more than 5 years prior to assessment showed that two of these patients presented with slight or insignificant cognitive deficit, two were moderately impaired, and six were still markedly or severely incapacitated.

There was a similar lapse of time in each age group (Figs. 1 and 3). In general, the psychometric investigation was performed at about the same period of time after aneurysmal rupture. Nevertheless, with respect to age the group profiles of impairment differed significantly, showing substantially worse dysfunction with increasing age; the younger patients revealed a considerably better cognitive capacity.

**Incidence of Cerebral Malfunction**

Altogether 15 patients (38%) showed an overall diminished short-term memory capacity for verbal as well as for nonverbal material. Verbal memory deficits alone...
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TABLE 3

<table>
<thead>
<tr>
<th>Impaired Verbal Capacity (SRB:1)</th>
<th>Memory Dysfunction</th>
<th>Visuo-Spatial Disorganization (BD)</th>
<th>Decreased Perceptual Speed &amp; Accuracy</th>
<th>Disturbed Concept Formation (WCST)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs), Sex, Location</td>
<td>Verbal</td>
<td>Spatial</td>
<td>BWV</td>
<td>BWE</td>
</tr>
</tbody>
</table>

* ICA = internal carotid artery; ACoA = anterior communicating artery; MCA = middle cerebral artery. For definitions of test abbreviations see Table 2.

were found in seven patients (18%) and nonverbal or spatial memory difficulties were seen in 11 patients (28%). Altogether, indications of insufficient memory functions were encountered in 33 patients, bringing the figure for learning and memory deficits up to a total of 83%. This high percentage was corroborated by the patients' own observations, with 23 patients specifically complaining of memory disturbances.

Disturbances in abstract and conceptual thinking were seen in 19 patients, while 18 patients were found deficient in cognitive flexibility, and visual reviewing ability. Evidence of a spatial disorganization as well as of a disturbance in visuo-spatial perception, analysis, and constructive ability was found in 14 patients. Impairment in perceptual speed and/or accuracy and fluctuations in attention and vigilance under extended performance conditions were shown by 11 patients.

Complaints Reported at Interview

Of 28 patients (70%) who reported changes in energy resources and energy consumption at the clinical interview (Fig. 2), 20 emphasized a decline in activity level.

J. Neurosurg. / Volume 62 / May, 1985
and energy investment. The symptoms predominantly reported were lack of initiative, withdrawal of interest in former activities, and diminished working capacity. Twenty-three patients were easily fatigued, and frequently experienced feelings of drained energy. Fourteen patients confessed to a need for rest or sleep during the daytime.

Difficulties in emotional adjustment, nonexistent prior to the hemorrhage, were claimed by 30 patients (75%), of whom 20 experienced anxiety, tension, undue concern, and apprehension. Feelings of irritability, inexplicable hostility, and weakened emotional control were reported by 14 patients. Eleven patients suffered from feelings of vulnerability and disproportionate sensitivity, and in 12 patients recurrent dysphoria and depressive mood swings were encountered. Altogether, 18 patients reported fundamental changes in temperament and mood.

Of 20 patients (50%) who reported mild or severe disturbances in their social demeanor, eight showed typical phobic reactions. Avoidance reactions, decreased self-confidence, difficulties in social management, and concomitant feelings of discomfort, anxiety, and fear of loss of control were frequent. In a few patients, in whom a tendency toward social sensitivity had been present before the hemorrhage, this had become considerably enhanced. Eight patients complained of decreased libido.

Twenty-three patients (58%) had disturbances in predominantly short-term memory functions, noticeably in activities of daily life. Thirteen patients complained of difficulties in concentration and attention. Eleven patients reported a diminished capacity for premeditation and planning, and described flaws in judgment and conceptual thought processes, restrictions in simultaneous intellectual capacity, and a lessened mental flexibility and adaptation.

Discussion

In most previous clinical studies of the outcome after aneurysmal SAH, patients who have returned to their previous occupation without neurological deficits are classified as having good or even excellent recoveries. However, cognitive, emotional, and conative disturbances are certainly underestimated or not obviously revealed in conventional examinations performed by neurologists, neurosurgeons, or maybe by the happy aneurysm surgeon himself. The results of this study, obtained with the current advanced techniques for assessment of cognitive disturbances, clearly demonstrate the presence of a diffuse SAH-induced encephalopathy in all patients, with impairment covering the whole spectrum of intellectual dysfunction from minor memory disturbances to numerous indications of disturbances of higher intellectual processes.

The indications of cognitive impairment displayed qualitative and sequential differences. Memory functions appeared to be the most susceptible to disturbances of the cognitive apparatus, and dysfunctions of this nature predominated among patients who showed slight to moderate disturbances. Patients with marked or severe cognitive dysfunction also invariably presented evidence of memory impairment of a verbal or spatial nature, or both. Deterioration of higher-order intellectual functions, such as perceptual reviewing ability, planning, integration of intellectual performance, and concept formation, was rarely found in the first two subgroups, whereas such disturbances constituted a major sign of impairment among the more severely affected patients.

A majority of patients experienced a considerable decrement in energy supplies and energy economy, resulting in a reduction in interests and activities or in increased fatigue and waning endurance. Feelings of anxiety, inappropriate concern, strain, and irritability were frequent. Alterations of mood and a tendency to mild depression were often reported. Self-maintenance was possible, although with some changes in social conduct and self-assertion. Cognitive dysfunction, especially disturbances of memory and attention, was reported by a number of patients.

There was an evident disagreement in self-reported complaints by means of the two methods used (Table 3). From a psychological point of view the discrepancy in attitude is understandable. It is certainly not unknown to the former patient that he or she has been fortunate enough to escape from what could have been a premature death. Consequently, it is in the interest of the ego and its adaptive functions to try to suppress symptoms and other reminders of the once-imminent disaster in order to live up to expectations of regained health. The patient will then minimize the significance of his experiences since the recognition of remaining symptoms would revive his suppressed fear of not being completely recovered from his illness or even of having another hemorrhage. To protect his self-esteem the patient may also disclose an unwillingness to admit any reduction of his intellectual capacity. The mechanisms of suppression are strongly felt in the clinical interview focusing on adjustment and reintegration, and the clinician through his face-to-face contact with the patient may circumvent these mechanisms. A routine questionnaire will not provide this advantage and many signs of maladjustment will go undetected by this means.

A patient's age rather than time elapsed since SAH seems to be a crucial determinant in the restitution of cognitive functions or, conversely, in the persistence of cognitive deficits. Even allowing a considerable time for the restitution process, a significant number of patients will still display evidence of serious cognitive dysfunction. It appears that the passage of 31 years is insufficient for completion of the recovery process. It may also be that sequelae that remain after such a period of time may be permanent. There was no obvious relationship between aneurysm location and quality of cognitive dysfunction (Table 3). We did not subdivide the patients in terms of severity of the initial bleed, although
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a relationship to cognitive impairment seems highly probable.

Drake has cautioned that surgery during the acute stage after SAH may precipitate cerebral vasospasm and cerebral dysfunction of immediate or delayed onset, and it remains an open question whether the encephalopathy shown by the patients in the present study was enhanced by early operation. This important question deserves further investigation of a similar group of patients subjected to operation at the late stage. It is relevant to point out that previous studies of patients with head trauma and massive traumatic SAH have shown patterns of cognitive disturbances similar to findings of the present study.

References


Manuscript received September 21, 1984.
This work was supported by grants from the Thorsten and Elsa Segerfalk Foundation for Medical Research, the Einar Björkland Foundation, and the Elsa Schmitz Foundation.
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