Predictors for cognitive impairment one year after surgery for aneurysmal subarachnoid hemorrhage

Introduction

The aim of the present article is to identify independent predictors for cognitive impairment one year after surgery for subarachnoid hemorrhage (SAH). It has become well recognized that patients surgically treated for SAH often struggle with persisting cognitive impairments despite being neurologically intact [4, 7, 9, 10, 13, 17, 23, 30, 36, 37, 39, 43]. Knowledge of the disease factors that influence long-term cognitive outcome after SAH is clinically important as such factors are possibly modifi-

Abstract

Objective To assess predictors for cognitive impairment one year after spontaneous subarachnoid hemorrhage (SAH). Evaluated predictors were the total amount of cisternal blood seen on computed tomography (CT) in the acute phase as measured by the Fisher grade, neurological grade at admission classified according to the Hunt and Hess scale, aneurysm site and patient’s age, gender and education level. Method 44 patients were operated by surgical clipping within 72 hours after CT verified aneurysmal SAH. After twelve months the remaining 42 patients were assessed by neuropsychological test, Beck Depression Inventory (BDI), the Glasgow Outcome Scale (GOS) and CT. Multiple regression analysis was conducted where predictor variables were independent factors and a global impairment index calculated for each patient was the dependent factor. Results The Fisher grade was the only independent predictor for neuropsychological impairment. Most patients had good neurological outcome as measured by the GOS and at the same time suffered from some degree of cognitive impairment at follow-up. Individual analysis of cognitive test scores showed mild to moderate dysfunction across multiple cognitive domains. Most frequent impairments were found in domains of memory, executive function and speed of information processing. Age below 50 years was associated with relatively better outcome. Conclusion The severity of cognitive impairment one year post SAH is predicted by the volume of blood in the subarachnoid space as measured by the Fisher score.

Key words cognitive impairment · neuropsychology · predictors · aneurysmal subarachnoid hemorrhage · Fisher grade
able. Information of long-term prognosis is essential to patients and their families and has extensive emotional and economic consequences [10, 12, 18, 22, 23, 47]. Existing studies still lack consensus concerning which disease factors are the most influential for cognitive dysfunction after SAH and makes predictions in the present study open. Heterogeneous results are probably due to the large number of possible pre-, peri-, and post-operative factors that may influence the brain and recovery of cognitive functioning [3, 10, 13, 23, 26, 30, 36, 37, 39, 42–44]. Differences in methodology between cognitive studies may also produce heterogeneous results such as differences in test batteries applied for assessment of cognitive functions, small sample sizes and intra-sample heterogeneity [1, 26, 27, 39]. Furthermore, recent studies have shown different patterns of recovery for different cognitive functions after the initial ictus; thus, the severity and type of cognitive impairment reported after SAH may vary as a result of assessment timing [9, 14, 37]. It is also possible that different disease factors registered at the time of SAH may have different impacts on cognitive functioning at different points in the recovery process. In the present study we have chosen a one-year interval for assessment of cognitive functions in accordance with previous assumptions that little functional recovery takes place after this point in time [6, 10, 17, 34, 37]. We evaluate the impact of each patient's neurological status prior to operation, the amount of subarachnoid blood on the initial CT scan, the localization of the aneurysm and patient's demographics on cognitive impairment.

### Patients and methods

#### Patients and general procedure

Forty-four patients were included, all operated by surgical clipping within 72 hours after CT-verified aneurysmal SAH. All patients were native Norwegians. At admission, each patient's neurological status was classified according to the Hunt and Hess grade [16] and amount of SAH according to the Fisher grade [8]. Aneurysm sites were registered. Two patients died from cardiac disease two weeks and eleven months after SAH, respectively. Twelve months after the SAH patients completed an outpatient follow-up. The follow-up included a neuropsychological examination which is described in detail below, scoring according to the GOS [21] as well as a CT examination. Two experienced neuroradiologists unaware of the patients' clinical status independently evaluated CT. In cases of disagreement, consensus was made. The presence of low attenuating areas indicating cerebral infarction was recorded. The study was approved by the Regional Committee for Medical Research Ethics. Patients' demographics and disease variables registered at admission are presented in Table 1.

#### Neuropsychological assessment

For neuropsychological testing only standardized and commonly used tests were applied. Patients were tested individually in a laboratory by an experienced assessor. The areas of neuropsychological functioning examined and the specific tests administered were as follows:

1. **Attention/sustained attention**: Digit Span subtest from the Wechsler Adult Intelligence Scale (WAIS) [46] and the Seashore Rhythm Test [33].
2. **Psychomotor speed**: Trail Making Test, parts A and B [33] and Stroop Color Word Test (reading speed), modified version [11, 40, 41].
3. **Memory**: two subtests from the Wechsler Memory Scale-Revised, the Verbal- and Visual Paired Associates, immediate and 60-min delayed recall [45].
4. **Language (word fluency)**: The Controlled Oral Word Association Test [25, 41].
5. **Cognitive flexibility/executive functioning**: Stroop Color Word Test (interference) [11, 40, 41] and a computer administered version of the Wisconsin Card Sorting Test [15].
6. **Simple and complex reaction time/speed of information processing**: a computerized version of the California Computerized Assessment Package™ 2ed [28, 29].
7. **Fine-motor functioning**: The Grooved Pegboard Test using the dominant and non-dominant hand [33]. In addition, symptoms of depression were measured according to BDI [2], which was included because of the confounding effects mood can have on cognitive performance. The upper limit for a normal score was 13 [2].

#### Calculation of impairment indexes

Standardized T-scores were calculated for the neuropsychological tests using published normative data for specific tests, which allows for a comparison of normal subjects who have similar demographic features. Our definition of abnormal performance was a score below one standard deviation from the normative mean (T-scores < 40) on any test within one of the seven domains. A T-score below 40 demonstrates sensitivity and specificity for the definition of impairment across brain-damaged and normal subjects [41]. A global cognitive impairment index was calculated as a score for each patient where the number of significant parameters (test results with T-scores below 40) was divided with the total number of neuropsychological parameters (total number of tests). This index gives values between 0.00 and 1.00 where an impairment index value of 0.00 is normal and a value of 1.00 is the most pathological.

#### Statistics

Associations between variables were examined with Pearson's product-moment correlations. Stepwise multiple regressions were used to

### Table 1

<table>
<thead>
<tr>
<th>Age (28–69)</th>
<th>Gender (M/F)</th>
<th>Education (10–17)</th>
<th>Hunt and Hess grade</th>
<th>Fisher grade</th>
<th>Aneurysm location</th>
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**AcomA** anterior communicating artery; **PcomA** posterior communicating artery; **MCA** middle cerebral artery