

Neuropsychological Changes Associated with Stenoses or Occlusions of the Carotid Arteries

A Comparative Psychometric Study

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Summary. A total of 33 patients with a relevant stenosis or occlusion of extracranial arteries were tested for a number of neuropsychological functions. Most of them [22] suffered from transient ischemic attacks, 6 from strokes, 5 were asymptomatic. Compared to an age-matched population of normals, patients showed an impairment in their mnemonic functions, and attention under stress as well as in their psychomotor function. The degree of neuropsychological impairment was independent of the unilaterality or bilaterality of carotid stenoses. The results illustrate the neuropsychological deficit even in asymptomatic patients and those with complete recovery from transient neurological deficits.

Key words: Extracranial vascular disease – Neuropsychological deficit

Zusammenfassung. In der vorliegenden Studie wurden 33 Patienten mit hämodynamisch relevanten Carotisstenosen oder -verschlüssen psychodiagnostisch untersucht. 22 litten an transitorisch ischämischen Attacken, 6 hatten einen leichten Schlaganfall erlitten, 5 waren asymptomatisch.

Im Vergleich mit der altersentsprechenden Normalpopulation waren die intellektuellen Funktionen intakt; es bestanden aber deutliche Einschränkungen im mnestischen Bereich, in der Aufmerksamkeit und im Bereich psychomotorischer Reaktionen. Für die Ausprägung der neuropsychologischen Ausfälle war es irrelevant, ob uni- oder bilaterale Stenosen im Carotiskreislauf vorlagen. Die Untersuchung zeigt, daß auch bei asymptomatischen Patienten und solchen mit reversiblen neurologischen Ausfällen bereits manifeste neuropsychische Störungen bestehen können.

Schlüsselwörter: Carotisstenose – Neuropsychologische Veränderungen

Introduction

Since the first report of a successful carotid endarterectomy in a patient with transient ischemic attacks (TIA) (Eastcott et al. 1954) this procedure is now performed routinely for the prevention of stroke. The decision for a surgical approach in the individual patient beside being determined by the assessment of the individual physical risk depends on the evaluation of the (transient) neurological deficit. The prophylactic effect of endarterectomy in patients with TIA is accepted, whereas its superiority to medical treatment is controversial for asymptomatic patients or those who have suffered from a minor stroke (Diener and Dichgans 1980).

Patients suffering from TIA, despite complete recovery from their neurological symptoms may show intellectual impairment. (Hemmingsen et al. 1982), but these complaints have not influenced the indication for surgery up to now. The present study in patients with extracranial vascular disease was undertaken to evaluate the frequency and severity of neuropsychological alterations in these patients as compared to a group of normals matched in age. Additionally we compared the performance of patients with TIA to the one of patients suffering from a minor stroke and a small group presenting with „asymptomatic“ stenoses or occlusions. We also investigated the possible influence of the severity of the extracranial vascular disease. For this purpose we first compared patients with unilateral and bilateral stenosis or occlusion of the carotid arteries and secondly patients with stenoses restricted to the carotid artery and patients with a combined disease of the carotid arteries and the vertebrobasilar system. The effect of endarterectomy on mental capacity is described in a subsequent report (Diener et al. 1984).

Methods and Material

Patients

Stenoses and/or occlusions of the extracranial arteries were diagnosed by direct Doppler sonography (Diener et al. 1983) and confirmed by angiography. Stenoses below 50% which are not detected by Doppler sonography were not included because of their minor hemodynamic significance. Doppler sonography revealed a unilateral carotid artery disease in 14, and bilateral stenoses or occlusions in 19 patients; 21 patients presented flow disturbances in the carotid system only, 13 had additional stenoses in the vertebrobasilar system; 5 patients were classified as asymptomatic, 22 had TIAs and 6 a minor stroke. Computertomography showed minimal ischemic lesions in all but 1 of the patients with a stroke, but also in 3 of the patients with TIA.

The age of patients ranged between 50 and 70 years (mean 60.9 ± 7.1) and most of them were men (29). Nearly half of them were still working at the time of the investigation, and educational background and their professions showed no difference to the average German population. The control group consisted of persons who were matched in age and educational background without clinical signs of a neurological or vascular disease.

Psychometric Methods

In order to assess the intellectual function of our patients we performed the „culture fair intelligence test“ (CFT scale 2 introduced by Cattell in the German adaptation of Weiss (1972)).

This test requires the reasonable arrangement, completion or correction of a series of symbols. It is nonverbal and evaluates general problem solving behavior e.g., "fluid general intelligence". Using the "digit symbol test" (DS) from the Wechsler test battery (1964) we investigated visual motor coordination and flexibility. The premorbid level of intelligence was tested by a multiple choice vocabulary test (MWT-B) introduced by Lehrl (1977).

Mnemonic function was tested using the "visual retention test" (VRT) of Benton and Spreen (1981). It demands the graphical reproduction of ten tables with geometrical figures after a short presentation. Correct reproductions and total errors were counted.

Attention under different amounts of stress was evaluated using the following tests:

1. "Number revision test" (Rev. T.) according to Marschner and Hamster (1980), a modification of the original Kraepelin test demanding the detection of errors in a series of simple arithmetic operations.
2. "Attention stress test d2" (Test d2) according to Brickenkamp (1978). The patient is asked to cancel all combinations

of a "d" with two primes in a series of "d" and "p" with combinations of one, three or four primes. This test is a variation of the old Bourdon test. In both tests (Rev. T., test d2) the patient had to correctly handle as many items as possible within a given time. The number of test items handled and the number of errors (accuracy) were counted.

3. The "attention set test" (AET) according to Hamster and Mayer requires subjects to cross out randomly distributed numbers on a digit table. The partial and total time scores were recorded.

Psychomotor functions were tested using the "Vienna reaction time apparatus" (Hamster 1983) investigating auditory and visual reaction time and speed and accuracy of choice reaction time to combined signals. Dimensions of personality were evaluated using the "Freiburg personality inventory" (FPI) with 12 scales (e.g. depressiveness, psychosomatic disorders, sociability, extraversion, and neuroticism; Fahrenberg et al. 1978). Two self-rating scales evaluated actual symptoms and the state of health: CIPS scales BL-BL' according to Zerssen and Koeller (1976) and EWL-K according to Janke and Debus (1978).

Table 1. Mean values (M) and standard deviations (SD) of psychometric tests in patients with carotid artery disease and controls in standard values

			Patients		<i>p</i>
			<i>M</i>	<i>SD</i>	
<i>Intellectual function</i> ^a					
Multiple choice vocabulary test	(MWT-B)	IQ	102.1	15.5	NS
Culture fair intelligence test	(CFT-2)	IQ	97.5	15.1	NS
Digit symbol test	(DS)	IQ	102.3	18.0	NS
<i>Mnemonic function</i>					
Visual retention test (VRT)					
Right productions		RP	5.5	1.7	
Total errors		RP	7.0	3.3	
Percentage of pathological test results		%	42.0		0.05
<i>Attention stress</i> ^b					
Attention set test	(AET)	SW	101.4	13.7	NS
Revision test	(Rev. T)	SW	96.3	10.9	NS
Attention stress test	(Test d2)	SW	93.8	8.9	0.05
<i>Psychomotor function</i> ^b					
Vienna reaction timer					
Visual reaction time		SW	90.5	11.8	0.05
Auditory reaction time		SW	93.3	11.4	0.05
Choice reaction time		SW	88.7	11.0	0.05
<i>Dimensions of personality</i> ^c					
Freiburg personality inventory (FPI)					
Scale 1 “psychosomatic disorders”		St	5.8	1.5	0.05
Scale 3 “depressiveness”		St	5.8	2.4	0.05
Scale 8 “social contacts”		St	5.7	2.4	0.05
BL-BL’ (list of complaints)		St	7.5	1.4	0.05

Standard values:

^a IQ M = 100 SD = 15

^b SW M = 100 SD = 10

^c St M = 5 SD = 1

RP = Raw points

All of these methods are routinely employed in our clinical practice. Their validity for the detection and evaluation of impaired neuropsychological capacity has successfully been demonstrated in recent studies (Hamster et al. 1982; Hamster 1983; Mayer et al. 1969).

Statistical analysis was performed using parametric tests for homogeneous or inhomogeneous variance. Furthermore we analyzed the data with a one way analysis of variance (ANOVA). The level of significance was set to $p = 0.05$.

Results

There was no significant difference between patients and controls both in age and, more important, in the premorbid level of intellectual functions as measured by the MWT-B. This test is a valid measure of the premorbid level of intelligence. The results show that our patients do not differ in education and/or professional background from the average German population.

There was also no difference between patients and controls concerning their intellectual functions in the MWT, CFT, and DS tests. Patients with stenoses and occlusions of the carotid arteries exhibited considerable and significant impairments in mnemonic functions (VRT), attention under stress (Test d2), psychomotor functions (Vienna reaction timer) and dimen-

sions of personality (FPI) as well as subjective complaints (BL-BL'). The patients had a higher number of psychosomatic complaints, were more depressed, and were socially less active than controls.

There were no differences between the groups unilateral and bilateral stenosis as measured by performance tests. They differed only with respect to 2 of the 12 dimensions of FPI test: the first describes patients with unilateral stenosis as being more dominant (scale 7) and the second as less active in their social contacts (scale 8).

Next we compared the results of psychodiagnostic testing in patients with stenoses or occlusions of the internal carotids with those of patients with combined internal and vertebro-basilar stenoses. There were no significant differences between these subgroups.

Finally we compared the clinically asymptomatic patients with patients suffering from TIAs and from minor stroke. The analysis of variance again showed no significant differences between these three subgroups.

Discussion

The 33 patients included in this study were selected on the basis of their neurological and Doppler sonographic symptoms, i.e., they had a stenosis or occlusion of their carotid and/

Table 2. Comparison of the patients with unilateral (Group I, $n = 14$) and bilateral (Group II, $n = 19$) internal carotid stenoses

		Group I “unilateral”		Group II “bilateral”		2 <i>p</i>
		M	SD	M	SD	
<i>Intellectual function</i>						
MWT-B	IQ	100.1	15.1	104.3	15.4	NS
CFT-2	IQ	97.5	15.1	97.8	14.8	NS
DS	IQ	100.0	15.1	104.2	19.1	NS
<i>Mnemonic function</i>						
VRT correct reproductions	RP	5.4	1.8	5.4	1.6	NS
VRT total errors	RP	7.5	3.3	6.8	3.5	NS
<i>Attention stress</i>						
AET	SW	97.1	13.3	105.9	13.4	NS
Rev. T.	SW	93.9	10.4	97.5	11.3	NS
Test d2	SW	92.4	7.5	94.3	9.5	NS
CFF	Hz	42.9	2.7	42.7	3.5	NS
<i>Psychomotor function</i>						
Vienna reaction timer						
Visual reaction time	SW	88.8	12.7	91.3	11.2	NS
Auditory reaction time	SW	93.5	13.0	93.3	11.5	NS
Choice reaction time	SW	89.0	13.7	88.5	10.6	NS
<i>Dimensions of personality</i>						
FPI						
Scale 7 (“aggressiveness”)	St	6.1	1.4	4.6	1.9	0.5
Scale 8 (“social contacts”)	St	4.1	2.5	6.6	2.0	0.2
EWL						
Scale A–O						NS
BL–BL’	St	7.2	1.9	7.7	1.1	NS

Table 3. Comparison of patients with isolated stenoses of the internal carotid artery (ICA) (Group I, $n = 21$) and patients with combined carotid and vertebrobasilar stenoses (VB) (Group II, $n = 12$)

		Group I ICA		Group II ICA + VB		2 <i>p</i>
		M	SD	M	SD	
<i>Intellectual function</i>						
MWT-B	IQ	104.6	14.4	102.3	18.4	NS
CFT-2	IQ	97.8	16.7	96.3	12.9	NS
DS	IQ	104.2	18.4	101.4	15.2	NS
<i>Mnemic function</i>						
VRT correct reproduction	RP	5.5	1.5	5.4	2.6	NS
VRT total errors	RP	6.9	2.9	7.3	4.1	NS
<i>Attention stress</i>						
AET	SW	101.1	14.7	103.0	11.9	NS
Rev. T.	SW	96.9	9.3	97.4	12.3	NS
Test d2	SW	93.2	8.9	95.7	9.6	NS
CFF	Hz	42.7	4.3	42.2	2.1	NS
<i>Psychomotor function</i>						
Vienna reaction timer						
Visual reaction time	SW	91.2	12.3	89.4	10.7	NS
Auditory reaction time	SW	93.6	11.9	93.0	11.9	NS
Choice reaction time	SW	86.9	10.6	92.5	13.1	NS
<i>Dimensions of personality</i>						
FPI						
Scale 1-9, E, N, M						NS
EWL						
Scale A-O						NS
BL-BL'	St	7.3	1.8	7.3	1.4	NS

or vertebral arteries and most of them suffered from TIA. Our psychometric study showed that the patients, taken as a group, on average had disturbances in their mnemonic functions, in attention under stress and psychomotor tests as compared to the normal population matched in age, whereas intellectual functions were normal. Consequently even patients with a normal neurological examination (asymptomatic, TIA) may still present with considerable neuropsychological incapacitation. It is not clear whether this dysfunction results from a multifarct dementia "in statu nascendi" (Hemmingsen et al. 1982) based on repeated thromboembolic episodes, or a low-flow-endangered brain (Whitten et al. 1981; Jacobs et al. 1983) due to hemodynamic insufficiency and/or to an intracranial manifestation of a more general arteriosclerosis in many of the brain vessels. A comparison of our results with the literature is difficult, since most studies include a higher proportion of patients with minor strokes, in which neuropsychological disturbances would be expected (Bornstein et al. 1981; Hemmingsen et al. 1982; Horne and Royle 1974; Jacobs et al. 1983; Williams and McGee 1964). Other studies were more concerned with the comparison of pre- and postoperative data (Goldstein et al. 1970; Perry et al. 1975). Haynes et al. (1976) performed intelligence and personality tests on 17 patients prior to endarterectomy and on 9 patients undergoing major surgery which was not neurological in nature and found better results in the control group. The control group in the study of

Kelly et al. (1980) included 17 peripheral vascular surgery patients who were compared to 35 carotid endarterectomy patients. The mean scores for the neuropsychological and personality test were not different in the two groups preoperatively. This is difficult to explain and could be due to the fact that many patients with peripheral vascular disease have undetected asymptomatic carotid stenoses (Diener et al. 1983).

There were no differences in our test results, whether the lesion of the carotid artery was uni- or bilateral. Similar results were found by Hemmingsen et al. (1982), whereas Drake et al. (1968) reported lower scores in psychometric testing from patients with bilateral lesions.

As in the study of Hemmingsen et al. (1982) patients with TIA could not be differentiated from those with minor stroke by means of psychological testing. This was also true for asymptomatic patients. Grobe et al. (1979) reported that 11% of their asymptomatic, 19% of TIA, and 40% of stroke patients revealed mental disturbances.

The fact that patients with extracranial vascular disease, even when asymptomatic or suffering from transient neurological symptoms frequently show clear mnemonic and psychomotor disturbances, stimulated us to investigate whether this insufficiency is a consequence of a reversible hemodynamic deficit and consequently can be improved by endarterectomy. The results of this study are reported in a subsequent paper (see Diener et al. 1984).

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