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*Stroke* 1998;29:2080-2086

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ISSN: 1524-4628

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# The CAMCOG: A Useful Screening Instrument for Dementia in Stroke Patients

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**Background and Purpose**—Most mental screening tests focus on the detection of cognitive deficits compatible with Alzheimer's disease. Stroke patients who develop a dementia syndrome, however, constitute a more heterogeneous group with both cortical and subcortical disturbances. We assessed the diagnostic accuracy of the CAMCOG (the cognitive and self-contained part of the Cambridge Examination for Mental Disorders of the Elderly) and the Mini-Mental State Examination (MMSE) for dementia in patients with a recent stroke.

**Methods**—In patients aged 55 and older who were admitted in the Rotterdam Stroke Databank, cognitive functioning was assessed between 3 and 9 months after the most recent stroke. The "gold standard" diagnosis of dementia was compatible with the criteria of the *Diagnostic and Statistical Manual of Mental Disorders, Third Edition, Revised*. The CAMCOG and MMSE scores were obtained independent of the diagnostic procedure.

**Results**—Of 300 consecutive patients, 71 (23.7%) were demented. Sixteen severely demented patients could not be tested and were excluded. The CAMCOG and MMSE scores were significantly related to dementia (both  $P < 0.0001$ ) in a logistic regression model. Receiver operating characteristic analysis showed that the CAMCOG was a more accurate screening instrument (area under the curve for CAMCOG, 0.95; for MMSE, 0.90). Two other clinical variables independently improved the diagnostic accuracy of the MMSE and CAMCOG: patients with a left hemispheric lesion had a lower (odds ratio, 0.3; 95% confidence interval, 0.1 to 0.7), and patients with hemorrhagic stroke had a greater chance of being demented (odds ratio, 3; 95% confidence interval, 1 to 10). The effect of left hemispheric lesion as an independent diagnostic factor could not be explained by selection or its association with aphasia alone.

**Conclusions**—The CAMCOG is a feasible instrument for use in patients with a recent transient ischemic attack or stroke. It is a more accurate screening tool for dementia than the MMSE, especially when type and site of stroke are taken into account. (*Stroke*. 1998;29:2080-2086.)

**Key Words:** cognitive screening ■ dementia ■ neuropsychological tests ■ stroke

In patients with a recent stroke, it is important to assess cognitive deficits in a quick and convenient but also reliable and accurate way. In the past, several mental status tests have been developed for this purpose: the Mini-Mental State Examination (MMSE),<sup>1</sup> Mental Status Questionnaire,<sup>2</sup> Short Portable Mental Status Questionnaire,<sup>3</sup> Cognitive Capacity Screening Examination,<sup>4</sup> Neurobehavioral Cognitive Status,<sup>5</sup> and the Short Blessed Test.<sup>6</sup> Although these tests do not provide the same amount and type of information as a full neuropsychological examination, they may be used for selecting patients in whom such an extended neuropsychological examination is necessary. Most brief cognitive screening instruments have been developed for the detection of dementia of the Alzheimer type and focus on orientation, memory, and higher cortical functions such as aphasia, apraxia, and agnosia. Aspects of cognitive functioning, such as slowing of

intellectual functioning, abstraction, retrieval and recognition, and visuo-perceptual abilities, are less well measured. Stroke patients who develop dementia, however, may have deficits in any cognitive domain. The dementia syndrome may be classified as subcortical in some and cortical in others. Previous studies in stroke populations<sup>7,8</sup> also suggest that brief mental status tests are relatively insensitive to specific brain lesions or focal cognitive deficits. Cognitive screening tasks predominantly contain verbally mediated items and therefore tend to exaggerate the extent of cognitive deficits in patients with left hemispheric lesions. Likewise, tests that emphasize verbal capacities may underestimate the consequences of right hemispheric lesions.<sup>9-11</sup> The question is whether these tests are valid tools in stroke patients.

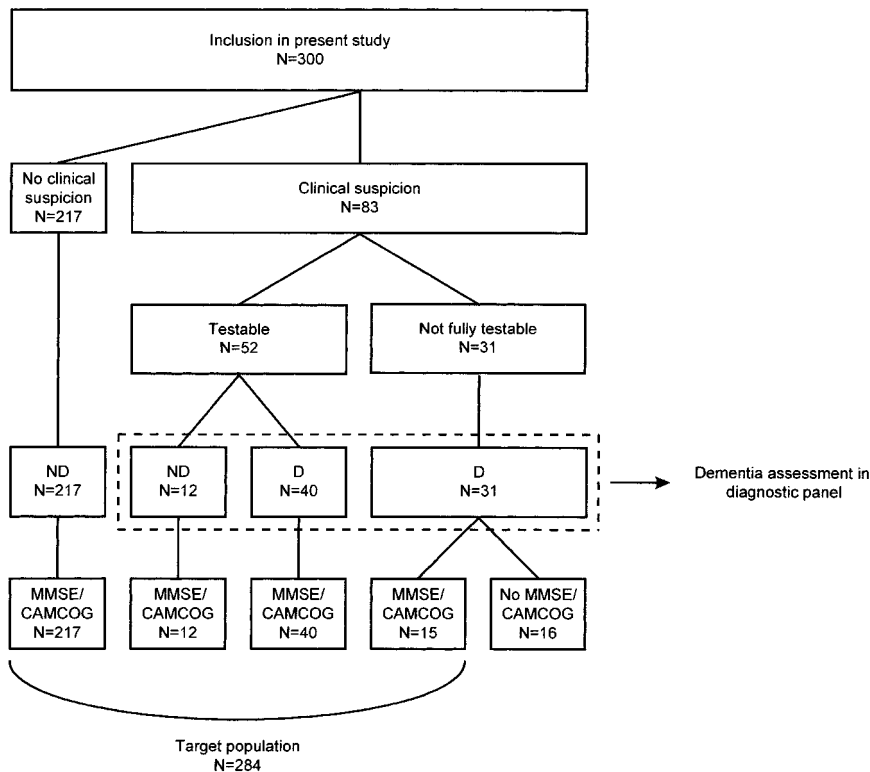
The CAMCOG is the cognitive and self-contained part of the Cambridge Examination for Mental Disorders of the

Received March 31, 1998; final revision received June 18, 1998; accepted June 19, 1998.

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**Figure 1.** Diagram of the diagnostic procedure for dementia. ND indicates not demented; D, demented.

Elderly (CAMDEX),<sup>12</sup> a standardized instrument for the diagnosis and grading of dementia. The CAMCOG consists of 67 items with a maximum possible score of 107, and it can be divided in several subscales: orientation, expressive and comprehensive language, memory (remote, recent, and learning), attention, praxis, calculation, abstraction, and perception. All items of the MMSE are also incorporated into the CAMCOG. Although the CAMCOG was also originally designed to diagnose primary degenerative dementia, it has an advantage over brief screening tests in that it covers a broader range of cognitive functions in a relatively short amount of time. It also detects mild cognitive deterioration and has few ceiling effects.<sup>12</sup> Studies of the CAMCOG have focused on the utility and validity of the complete CAMDEX.<sup>12-15</sup> In most of these studies the CAMCOG cutoff point of 79/80 suggested by Roth et al<sup>12</sup> seemed satisfactory for discriminating between normal subjects and demented patients. Lindeboom et al<sup>16</sup> reviewed some psychometric properties of the CAMCOG and found that it was stable and reliable and differentiated well between normal cognitive functioning and mild cognitive impairment. So far, little is known about the diagnostic value of the CAMCOG in a stroke population. Somatic handicaps as well as cortical disturbances such as aphasia or neglect may have a negative influence on its accuracy.

In this study, we investigated the diagnostic value of the CAMCOG as a screening instrument for poststroke dementia in comparison with the MMSE. Furthermore, we assessed the role of other clinical factors that could confound or modify the relationship between the screening test results and the presence of dementia.

## Subjects and Methods

### Subjects

Patients were recruited from the Rotterdam Stroke Databank, a prospective registry of patients with a transient ischemic attack (TIA), ischemic stroke, or primary intracerebral hemorrhage who were admitted to the Department of Neurology of the University Hospital Rotterdam. From March 1, 1993, until January 15, 1996, all consecutive patients who met the criteria for enrollment in the Dutch Vascular Factors in Dementia Study were entered.<sup>17</sup> Patients had to be 55 years or older and to have had a TIA with neurological signs on examination, an ischemic stroke, or intracerebral hemorrhage. Patients were excluded when a reliable assessment of dementia could not be made because of aphasia (ie, a score of less than 3 on the Aphasia Severity Rating Scale from the Boston Diagnostic Aphasia Examination),<sup>18</sup> severe sensory handicaps (eg, deafness or blindness), persistent impairment in consciousness, severe psychiatric symptoms, or insufficient command of the Dutch language. Additional exclusions were a TIA without neurological signs, concomitant primary cerebral disorder, or severe comorbidity with a short life expectancy. Informed consent was obtained from all patients or from close relatives in case of impaired judgment in the patient.

### Procedure

The clinical characteristics of the patients at baseline were assessed shortly after admission to the hospital. We obtained detailed information about cardiovascular risk factors, stroke characteristics, and premorbid mental and physical status. In addition to a full neurological examination, ancillary investigations consisted of standardized blood tests, chest x-ray, CT scanning and/or MRI of the brain, duplex scanning of the carotid arteries, and a cardiac analysis. Premorbid cognitive functioning was established by an interview with a close relative and the score on the Blessed Dementia Scale. Education was categorized by the number of years of schooling completed. Between 3 and 9 months after stroke onset, cognitive functioning was assessed by a neurologist, based on clinical observation, the information of a close informant, and the score on the Blessed Dementia Scale. In case of any suspicion of cognitive decline, patients were invited for

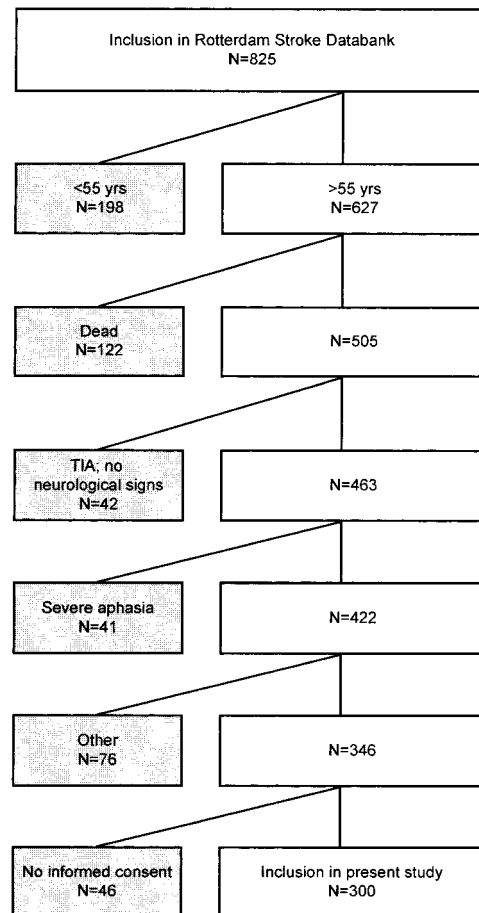
an extensive neuropsychological examination. We used the Aphasia Severity Rating Scale of the Boston Diagnostic Aphasia Examination to assess the presence and severity of aphasia. A score of 6 indicates no aphasia, and scores of 5, 4, and 3 indicate mild to moderate aphasia. A psychiatric examination was carried out in all demented patients to assess the presence of depression.

The “gold standard” diagnosis of dementia was based on the results of an extensive neuropsychological examination, clinical presentation, and information from a close relative. Figure 1 represents the diagnostic procedure for dementia. The extensive neuropsychological examination was carried out in all patients in whom there was any suspicion of dementia or cognitive decline. If patients could not be tested because of cognitive deficits or if they refused to cooperate further, the extensive neuropsychological evaluation was not performed. In some patients only a limited number of tests could be administered. The extensive neuropsychological examination consisted of an intelligence test (either the shortened version of the Groninger Intelligence Test,<sup>19</sup> a Dutch intelligence test, or when this could not be administered, Raven’s Colored Matrices,<sup>20</sup> a nonverbal intelligence test). The shortened form of the Boston Naming Test (the Consortium to Establish a Registry for Alzheimer’s Disease [CERAD])<sup>21</sup> was used to examine word-finding difficulties. Memory was evaluated with Word List Memory (CERAD)<sup>21</sup> and the Rivermead Behavioral Memory Test.<sup>22</sup> We used Digit Span forward and backward (Wechsler Adult Intelligence Scale [WAIS])<sup>23</sup> to assess the span of immediate verbal recall and also as a measure for attentional capacity. Parts of the Trail-Making Test<sup>24</sup> and the Stroop color word test<sup>25</sup> were also used to examine attention. Scores on verbal fluency (animals, occupations, letter B), Stroop color word test part III,<sup>25</sup> and Trail-Making Test B<sup>24</sup> served as indicators for the level of executive functioning. Proverbs and similarities (WAIS)<sup>23</sup> provided a measure for abstraction and verbal concept formation. Visuoconstructive ability was examined by copying the drawing of a circle, diamond, two overlapping rectangles, and a cube (CERAD).<sup>21</sup> Visual perception and spatial orientation were examined by Judgment of Line Orientation.<sup>26</sup> Based on clinical presentation, information from a close relative, the score on the Blessed dementia scale, and the neuropsychological test results, a final judgment of cognitive functioning was made by a diagnostic panel consisting of two neurologists, a neuropsychologist, and a trained physician. For the assessment of dementia, the criteria of the *Diagnostic and Statistical Manual of Mental Disorders, Third Edition, Revised*,<sup>27</sup> were used. Further subclassification of dementia took place according to the research criteria of the NINDS-AIREN International Workshop.<sup>28</sup>

Independent of the diagnostic procedure, the MMSE and the Geriatric Mental Status<sup>29</sup> and the Dutch version of the cognitive and self-contained part of the CAMDEX,<sup>30,31</sup> the CAMCOG, were administered in all patients.

### Statistical Analysis

For the comparison of the clinical characteristics of the demented and nondemented patients, Student’s *t* test and a  $\chi^2$  test were used when appropriate. The relationship between clinical characteristics and dementia was described by means of odds ratios (ORs) with a 95% confidence interval (CI). The ORs for the dichotomous variables were estimated by contingency table analysis, and for the CAMCOG and MMSE by means of logistic regression. To determine the influence of other diagnostic information independently of the MMSE or CAMCOG score, multiple logistic regression was used. The diagnostic accuracy of the CAMCOG and the MMSE, with and without adjustment for other diagnostic factors, was compared by receiver operating characteristic (ROC) curves, by measuring the area under the curve. The statistical significance of the regression models was assessed by a standard likelihood ratio test; the fit was assessed by means of the Hosmer-Lemeshow  $\chi^2$  test and by plotting observed and expected numbers of patients by deciles of the predicted probabilities. All statistical analyses were carried out using Stata software.<sup>32</sup>



**Figure 2.** Diagram of the process for selection of patients for the present study.

### Results

From the 825 patients who were entered into the Rotterdam Stroke Databank, 198 were younger than 55 years of age, 122 died within 3 months after stroke onset, 42 had a TIA without any sign appearing during neurological examination, 41 had severe aphasia, another 76 were excluded for various other reasons (eg, moved out of the region, did not speak Dutch, and had a short life expectancy because of other intracranial pathology), and 46 did not give informed consent (Figure 2). Of the remaining 300 patients who met the criteria for inclusion in The Dutch Vascular Factors in Dementia Study, 16 were excluded from the present study because the CAMCOG could not be administered due to severe dementia. The clinical characteristics of the 284 study patients are summarized in Table 1. The mean age was approximately 70 years, and 40% were female. One sixth of the patients had had a TIA, and a little more than one tenth an intracerebral hemorrhage. Of the demented patients in our study population, approximately one quarter were diagnosed with possible Alzheimer’s disease with cerebrovascular disease; the other demented patients were classified as having possible or probable vascular dementia. Aphasia was present in 7% of all patients. Demented patients scored significantly lower (on average, 25 points) on the CAMCOG (95% CI, 22.1 to 27.9) than nondemented patients. Demented patients were on average 4.8 years older (95% CI, 2.5 to 7.1), and they

**TABLE 1. Baseline Characteristics of the Study Population**

	Total Study Group, n=284	Not Demented, n=229	Demented, n=55
Age*	69.2 (8.1)	68.2 (8.0)	73.0 (7.3)‡
Years of education*	8.7 (3.1)	9.0 (3.0)	7.6 (2.9)§
Female sex†	114 (40)	84 (37)	30 (55)
CAMCOG*	83.3 (14.1)	88.2 (8.7)	63.2 (14.1)‡
MMSE*	25.4 (4.3)	26.7 (2.7)	19.9 (5.2)‡
"Prestroke" Blessed score >0†	26 (10)	6 (3)	20 (37)‡
Type of stroke†			
TIA	46 (16)	43 (19)	3 (5)
Ischemic infarction	203 (71)	164 (71)	39 (71)
Intracerebral hemorrhage	35 (12)	22 (10)	13 (24)§
Site of stroke†			
Right hemisphere	133 (47)	104 (45)	29 (53)
Left hemisphere	116 (41)	100 (44)	16 (29)
Infratentorial	35 (12)	25 (11)	10 (18)
Dementia type†			
Possible VaD			5 (9)
Probable VaD			35 (64)
Possible AD+CVD			15 (27)
Aphasia†	19 (7)	16 (7)	3 (5)
Apraxia†	9 (3)	3 (1)	6 (11)§
Neglect†	15 (5)	4 (2)	11 (20)‡
Hemianopia†	22 (8)	10 (4)	12 (22)‡
Facial paralysis†	54 (19)	36 (16)	18 (33)§
Any arm paresis†	69 (24)	49 (21)	20 (36)
Any leg paresis†	64 (23)	44 (19)	20 (36)§

VaD indicates vascular dementia; AD+CVD, Alzheimer's disease with cerebrovascular disease.

\*Values are means with standard deviations in parentheses.

†Values are number of patients with (column) percentages in parentheses.

‡Demented patients significantly different from nondemented patients ( $P<0.001$ ).

§Demented patients significantly different from nondemented patients ( $P<0.01$ ).

||Demented patients significantly different from nondemented patients ( $P<0.05$ ).

were more often female. They had on average 1.4 fewer years of education than nondemented patients (95% CI, 0.5 to 2.3). Neurological deficits, such as the presence of apraxia, neglect, hemianopia, facial paralysis, and paresis of arm or leg, were associated with dementia, but aphasia was not. Table 2 gives the corresponding ORs with 95% CIs for each factor by itself. In our study, each point increase in the CAMCOG score decreased the odds of dementia by 0.83, and each point increase in the MMSE score decreased the odds of dementia by 0.64. Although the relative odds reduction per point is larger for the MMSE, the CAMCOG is by far the better test, because the range of possible scores is larger (30 versus 107). ROC analysis shows that the CAMCOG was more accurate in screening for dementia than the MMSE (area under the ROC curve: MMSE, 0.90, versus CAMCOG, 0.95) (Figure 3). We could improve the predictions by adding other diagnostic factors: patients with a left hemispheric lesion had a 3 times lower risk of dementia, independent of the CAMCOG or MMSE score, and patients with a hemorrhagic lesion had an approximately 3 times higher risk of dementia independent of test score. In univariate analyses, TIA was related to a reduced risk of dementia. In the multiple

regression model, however, TIA was not significantly related to a reduced risk of dementia in our study population. Age, gender, and education are known to influence screening test scores, but they showed no significant relation to the presence of dementia and the CAMCOG score in our study. After adjusting for site and type of stroke, the area under the curve increased by 0.01 in both curves. The predictions based on the MMSE were always less accurate than CAMCOG-based predictions, even when they were adjusted for type and site of stroke. The predictions based on the CAMCOG with adjustment for the 2 diagnostic factors appeared to be the best, as the area under the ROC curve was largest (0.96). The CAMCOG had the best overall fit (Table 3). Figure 4 shows the relationship between the risk of dementia and the CAMCOG score in our study, adjusted for type and site of stroke. The additional diagnostic factors have a maximum effect in the middle range of the CAMCOG scores. In our study approximately 45% of the patients have a CAMCOG score between 55 and 87. For example, the predicted probability of dementia in a patient with a CAMCOG score of 75 would be 30% in our study. Taking

**TABLE 2. Relationship Between Clinical Characteristics and the Presence of Dementia**

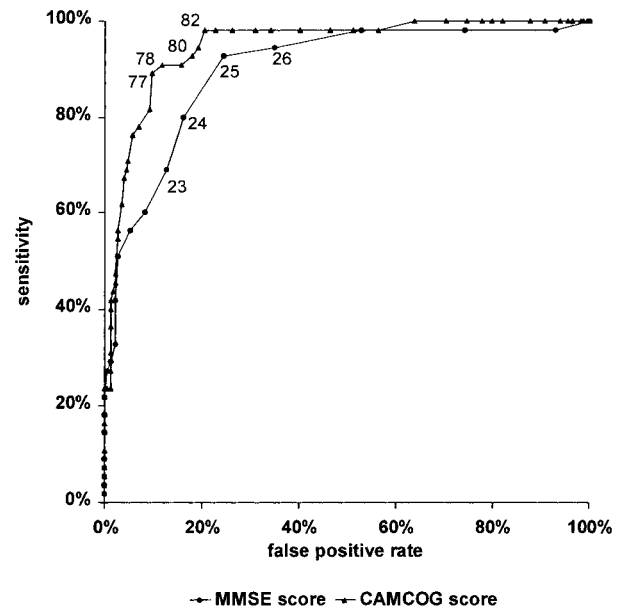
Characteristic	OR	95% CI
<b>Univariate analysis</b>		
CAMCOG score	0.83	0.79–0.87*
MMSE score	0.64	0.57–0.72*
Age	1.08	1.04–1.12*
Female sex	2.1	1.1–3.7
Years of education	0.83	0.73–0.93
TIA	0.25	0.08–0.77
Left hemisphere	0.5	0.3–1.0
Intracerebral hemorrhage	2.9	1.4–6.2
Aphasia	0.8	0.2–2.6
Apraxia	9.7	2.6–36.8
Neglect	11.2	3.9–32.4
Arm paresis	2.1	1.1–3.9
Leg paresis	2.4	1.3–4.5
Hemianopia	6.1	2.5–14.7
<b>Multiple regression model</b>		
CAMCOG score	0.83	0.79–0.87
Left hemispheric lesion	0.3	0.1–0.9
Intracerebral hemorrhage	3.1	1.0–9.7
MMSE score	0.63	0.56–0.71
Left hemispheric lesion	0.3	0.1–0.7
Intracerebral hemorrhage	2.6	1.0–7.4

\*Estimated by logistic regression; odds ratios per unit increase.

into account that this patient had a left-sided ischemic stroke would lower the probability of dementia to 10%, whereas a patient with a right-sided hemorrhagic stroke and the same CAMCOG score would be much more likely to be demented (probability of 60%).

**Discussion**

We investigated the diagnostic accuracy of the CAMCOG in patients with a recent stroke in a prospective study by



**Figure 3.** Receiver operating characteristic curves to determine the diagnostic accuracy of the CAMCOG and the MMSE.

comparing the CAMCOG with a final gold standard judgment of cognitive functioning. The CAMCOG was more sensitive and specific than the MMSE as a screening instrument for dementia in stroke patients. Despite its length and multiplicity, the CAMCOG appeared well administrable in an elderly stroke population. Of the 300 patients, the CAMCOG could be administered in 95% of the patients and the MMSE in 97%. The experience with the CAMCOG in stroke populations is limited. Kwa et al<sup>33</sup> found that the CAMCOG was administrable in 88% of an ischemic stroke population, which also included patients younger than 55 years. Since their main interest was in the extent to which the CAMCOG is feasible in an ischemic stroke population, they included all aphasic patients and allowed adaptations in administration, such as the use of gestures. We excluded patients with a severe aphasia because differentiation between dementia and severe aphasia is very difficult, and sometimes impossible, even for experienced neuropsychologists who use a large test battery.

**TABLE 3. Observed and Predicted Number of Demented Patients, According to the 4 Logistic Regression Models, by Quintiles of the Predicted Probabilities**

CAMCOG* P=0.21		MMSE† P=0.02		CAMCOG Adjusted‡ P=0.19		MMSE Adjusted§ P=0.05	
Observed	Predicted	Observed	Predicted	Observed	Predicted	Observed	Predicted
0	0.4	1	1.5	0	0.3	0	1.0
1	1.4	2	4.7	0	0.7	0	2.3
0	2.8	1	2.4	1	2.6	6	3.2
12	9.2	18	10.7	13	8.7	15	11.9
42	41.2	33	35.7	41	42.7	34	36.7

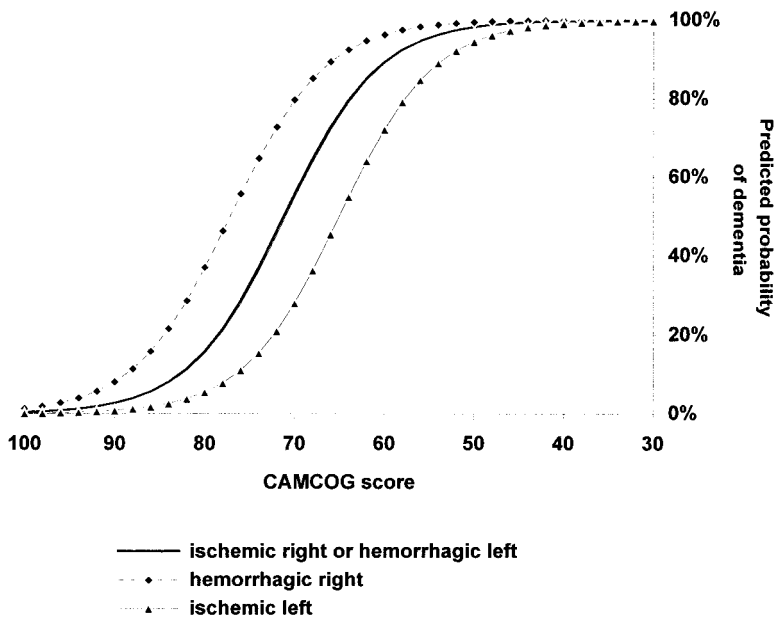
Fit was assessed by means of the Hosmer-Lemeshow  $\chi^2$  test.

\* $O = e^{13.2 + (-0.19 \times C)}$

† $O = e^{9.2 + (-0.44 \times M)}$

‡ $O = e^{13.5 + (-0.19 \times C) + (1.13 \times H) + (-1.18 \times L)}$

§ $O = e^{9.8 + (-0.46 \times M) + (0.97 \times H) + (-1.3 \times L)}$ , where O indicates odds of dementia; C, CAMCOG score; M, MMSE score; L, presence (1) or absence (0) of left hemispheric lesion; and H, presence (1) or absence (0) of hemorrhagic stroke.



**Figure 4.** Relationship between the risk of dementia and the CAMCOG score, with adjustment for type and site of stroke, determined by logistic regression.

The CAMCOG may be administrable in such patients, but the score is meaningless because it remains unclear to what extent the total score is determined by the presence of dementia or by aphasia.

The finding that the CAMCOG is a more sensitive and specific screening instrument than the MMSE in an elderly stroke population is not surprising, as the CAMCOG contains more items on memory, language, and construction and allows a more differentiated judgment about these functions than the MMSE. Furthermore, the CAMCOG comprises items on more cognitive domains in comparison with the MMSE, by adding subtests for abstraction, fluency, and perceptual tasks. It is therefore a priori quite likely that the CAMCOG is more sensitive and specific than the MMSE in a heterogeneous group such as stroke patients. On the other hand, the addition of items is, by itself, not enough to increase sensitivity and specificity. Grace et al<sup>8</sup> performed a study in which the original MMSE was compared with a modified version, the 3MS. This modified version contains the items of the original MMSE that were given a different weight, and extra items such as abstraction and fluency were added. In that study, the 3MS and MMSE had a similar overall classification accuracy, which was adequate for patients with left hemispheric strokes and poor for patients with right-sided strokes. In our study, the CAMCOG score seemed to overestimate the risk of dementia in patients with a left hemispheric stroke compared to those with a right hemispheric stroke, which may indicate that the CAMCOG tends to overemphasize focal cognitive deficits in these patients.

Previous studies<sup>34-37</sup> suggest that age and education level are associated with dementia and also with performance on the CAMCOG.<sup>16,38</sup> In our study, age and education had no additional diagnostic value in a multiple logistic regression model. One obvious explanation is that these factors are already accounted for in the CAMCOG score, as they are associated with dementia alone. We found that apart from the CAMCOG score, only type and site of stroke were useful in

predicting the probability of dementia 3 months after stroke. Patients with an intracerebral hemorrhage had an approximately 3 times greater risk of dementia after stroke than patients with a TIA or ischemic stroke, whereas patients with a left hemispheric stroke had a 3 times lower risk than patients with a right hemispheric stroke. The finding that apraxia, mainly a consequence of left hemispheric lesions, was strongly associated with the presence of dementia in an univariate analysis seems to be incongruent with this finding. The number of patients with apraxia, however, was small and therefore may have had little effect on the total group of patients with left hemispheric stroke.

Patients with left hemispheric stroke were less likely to be demented 3 months after stroke even after adjustment for other diagnostic factors, which is not in agreement with some other studies<sup>39-41</sup> which found that a left hemispheric stroke increases the risk of cognitive impairment or dementia. There are some explanations for our finding. First, we may have overestimated the role of mild and moderate aphasia in neuropsychological test scores and therefore underestimated the extent of general cognitive decline. The proportion of aphasic patients in our study, however, was equal for demented and nondemented patients, and also when we included the demented patients in whom a CAMCOG was not administrable. Second, since patients with a severe aphasia were excluded because this prevented a reliable assessment of dementia, we excluded more massive left hemispheric strokes as opposed to massive right hemispheric strokes. In our study, however, patients with left hemispheric stroke did not differ from those with right hemispheric stroke with respect to the presence of hemianopia, facial paresis, or arm or leg paresis.

In conclusion, the CAMCOG is easily administered and is an accurate screening tool for dementia in patients with a recent stroke. Our study results suggest that the CAMCOG has additional diagnostic value compared with the MMSE, especially when type and site of stroke are taken into account. A prospective study in a different but comparable stroke population is needed to confirm our results.

## Acknowledgments

The Dutch Vascular Factors in Dementia study is supported by the Netherlands program research on aging, NESTOR, funded by the Ministry of Education, Cultural Affairs and Science and the Ministry of Health, Welfare and Sports. The Rotterdam Stroke Databank is supported by the Stichting Neurovasculair Onderzoek Rotterdam.

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