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A follow-up study of cognitive impairment due to inferior capsular genu infarction

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Abstract Abulia, memory loss, other cognitive deficits, and behavioral changes consistent with dementia can follow an inferior capsular genu infarction, but only little is known about the time course of these disturbances. The present study describes the long-term outcome of cognitive defects in four patients with inferior capsular genu infarction who underwent a neuropsychological examination within 3 and 12 months of onset. Three patients had infarcts in the inferior genu of the left internal capsule and had similar symptoms in the acute phase: disorientation, memory loss, language impairment, and behavioral changes. The patient with right-side infarct showed memory impairment and behavioral

changes. Three patients had deficits in one or more cognitive domains on the first assessment, but none was demented. By the second evaluation all subjects had improved. In two patients there were a moderate memory defect persisted and a language disturbance. Improvement in these disturbances during long-time follow-up demonstrates that there are alternative pathways that reestablish the functional connections damaged by the strategically located capsular genu infarct. Inferior capsular genu infarction is not a cause of persisting “strategic infarct dementia.”

Key words Subcortical infarction · Cognition · Dementia · Stroke outcome

Introduction

“Focal forms” of vascular dementia were first described by Delay and Brion [14]. Several clinical studies have confirmed the relationship between ischemic damage to specific cortical areas such as the angular gyrus, inferomesial temporal lobe, and medial frontal lobe [26] and dementia. Subcortical infarcts such as those involving the thalamus [9, 18], caudate nucleus [10, 11] and internal capsule [1, 23, 24, 25] are also reported as producing a frontal-lobe syndrome with abulia, hypokinesia, amnesia, and inattention. Tatemichi et al. [30] identified the genu of the internal capsule as a relevant site for dementia. They described six patients who, following acute capsular genu infarction, showed fluctuating alertness, inattention, memory loss, apathy, abulia, and psychomotor retardation within

6–12 weeks of onset. Four of the five patients with left-sided lesions still displayed severe memory impairment and other cognitive deficits consistent with dementia 10 weeks–10 months after the capsular genu infarction. There are no other reported series investigating the time course of behavioral and cognitive deficits associated with inferior capsular genu infarcts.

Patients and methods

The patient population in this study included stroke patients admitted to the Santa Maria Hospital Stroke Unit or evaluated at the Stroke Outpatient Clinic between November 1995 and November 1997 and participating in a prospective study of dementia and cognitive impairment after first ischemic or hemorrhagic stroke. From these we retrieved the patient data on those who showed either language, cognitive, or behavioral changes associated with an infarct of the inferior part of the internal capsule. Patients with infarcts on

Table 1 Neuropsychological evaluations

Cognitive domains	Tests
Global mental state evaluation	Mini-Mental State Examination
Verbal and visual memory	Wechsler Memory Scale
Orientation	Temporal, Spatial, and Personal Orientation Test
Attention	Letter Cancellation
Language	Token Test
Visual neglect and visuo-constructural abilities	Draw by Copy, Wechsler Adult Intelligence Scale Block Design Subtest, Raven Progressive Matrices
Executive functions	Verbal Initiative, Luria's Graphomotor Sequences
Motor control	Motor Alternate Sequences
Praxis	Performance of Learned Movements by Verbal Instruction (Ideomotor and Buccofacial Praxis)
Functional Activities	Blessed Dementia Scale
Depression	Hamilton Depression Scale

other locations or multiple lacunae were excluded. Whenever possible subjects underwent a neuropsychological evaluation 3 and 12 months after the stroke.

Neuropsychological examination included the Mini-Mental State Examination (MMSE) [15] for global assessment of the mental state and a complementary battery as described in Table 1. Cognitive

domains assessed were memory, orientation, attention, language, spatial attention and visuospatial ability, executive functions, motor control, calculation, and praxis. All tests had previously been validated in the Portuguese population [16, 21]. MMSE normative values took account of educational levels: severe impairment was considered when scores were below 16 in subjects who had never attended to school; below 23 in patients who had had at least 1 year of schooling; and below 28 in those with more than 11 years of schooling. In the complementary neuropsychological battery, patients were classified as having mild cognitive impairment in a particular test when they scored 2 SD below the mean (for their age, gender, and educational level), moderate impairment when they scored below 3 SD, and severe impairment when they scored 4 SD or more below the mean. The Hamilton Depression Scale (HDS) [22] was used to assess depressive symptoms. Depression was diagnosed when the HDS score was 13 or higher [2]. We used the Blessed Dementia Scale (BDS) [4] to evaluate the impact of cognitive impairment on daily life activities; functional impairment was considered when patients scored higher than 4. Dementia was defined according to the NINDS-AIREN criteria for vascular dementia [26].

Results

We found seven cases with infarcts on the inferior part of the internal capsular genu. Three were excluded because they had other hemispheric lesions. The four patients' characteristics and scores on neuropsychological tests are summarized in Tables 2 and 3.

Table 2 Patient characteristics

	Patient 1	Patient 2	Patient 3	Patient 4
Gender	Male	Male	Female	Female
Age	64	70	59	64
Years of schooling	7	11	4	0
Side of lesion	Left	Left	Left	Right

Table 3 Neuropsychological test scores at 3 and 12 months

	Patient 1		Patient 2		Patient 3		Patient 4	
	3 M	12 M	3 M	12 M	3 M	12 M	3 M	12 M
MMSE	30	30	24 ^b	28	27	28	22	23
Memory with Interference	13	11	7 ^c	10	11	13	10	13
Logical Memory	10	9	4 ^c	2.5 ^b	4.5	3	3 ^a	7
Visual Memory	4 ^a	5	5	5	6	6	2	2
Orientation	15	15	12 ^c	14	15	15	10 ^b	11
Letter Cancellation	8	6.9	5.7	6.5	2.7	6	3.2	2.1
Token Test (mod)	13 ^b	13 ^b	17	17	17	17	17	17
Draw by Copy	11	14	13	13	11	11	12	12
Wechsler Adult Intelligence Scale Cubes	36	29	28	28	24	24	14	14
Raven Progressive Matrices	10	10	11	10	8	8	6	6
Verbal Initiative	6 ^c	8 ^b	10	12	13	11	15	12
Graphomotor Initiative	2	2	2	2	2	2	2	2
Ideomotor and Buccofacial Praxis	12	12	12	12	12	12	12	12
Blessed Dementia Scale	2	0.5	3	3	0.5	1	5 ^a	2.5
Hamilton Depression Scale	3	5	9	8	0	2	7	2.5

^aMild impairment

^bModerate impairment

^cSevere impairment

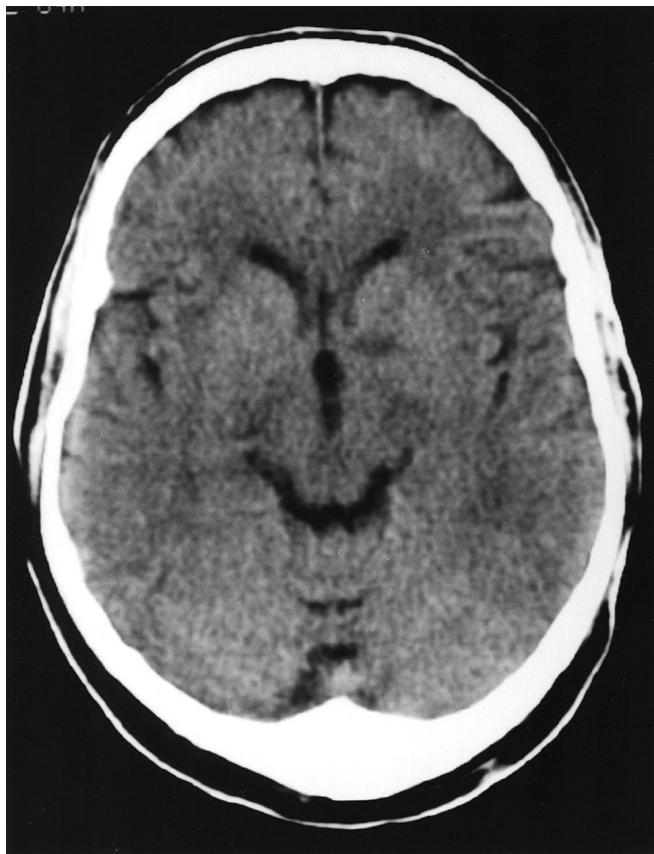


Fig. 1 Patient 1: CT obtained 48 h after the stroke onset, showing an infarct on the left capsular genu

ing long runs of speech, and a right emotional facial palsy. Computed tomography showed an infarct on the inferior part of the left internal capsule genu (Fig. 1). Duplex examination and electrocardiography were normal. Three months later he had returned to his social activities and complained only of decreased enthusiasm. On neuropsychology evaluation he showed mild memory impairment, moderate deficit in verbal fluency, and a language comprehension defect. Twelve months after the stroke, on the second neuropsychology evaluation, he scored low on the Token test but had no other deficit or impairment. He mentioned occasional sadness but did not fulfill depression criteria.

Patient 2 was a 70-year-old hypertensive, former smoker, and retired army officer who had a sudden onset of mild right upper limb weakness, dysarthria, and trouble in word finding. CT showed an infarct on the inferior part of the left internal capsule genu (Fig. 2). Doppler showed a less than 50% ipsilateral carotid stenosis. Electrocardiography and echocardiography were normal. He recovered from his motor deficit, but anomia persisted, and his family reported apathy and decreased initiative to start conversations. He also complained of decreased initiative and enthusiasm. On neuropsychological evaluation he had a low score on the MMSE (24 points) because he had temporal disorientation



Fig. 2 Patient 2: CT obtained 3 months after stroke onset, showing an infarct on the inferior part of the genu of the left internal capsule

and failed in the memory items. In the complementary battery he showed a moderate defect in all memory tests but had no deficits in other cognitive domains. On the second neuropsychology evaluation 12 months upon the stroke his MMSE score improved (28 points). His memory impairment persisted, and he still complained of some irritability and decreased enthusiasm.

Patient 3 was a 59-year-old hypertensive housewife. Her close relatives reported a subacute onset of word finding troubles and difficulty in recalling recent events. On examination she produced occasional semantic paraphasias and could not recall any of the three names 1 min later. CT and magnetic resonance imaging (MRI) showed an infarct on the genu of the left internal capsule, probably not involving the head of the caudate nucleus (Fig. 3). Carotid duplex examination was normal. Ten months after the stroke she underwent a neuropsychological examination and showed neither cognitive nor functional deficits. Meanwhile she had returned to her previous household activity. Eighteen months after stroke she had no cognitive, emotional, or functional deficits or complaints.

Patient 4 was a 64-year-old hypertensive, hypercholesterolemic housewife who reported having a sudden onset of forgetfulness and apathy perceived as diminished

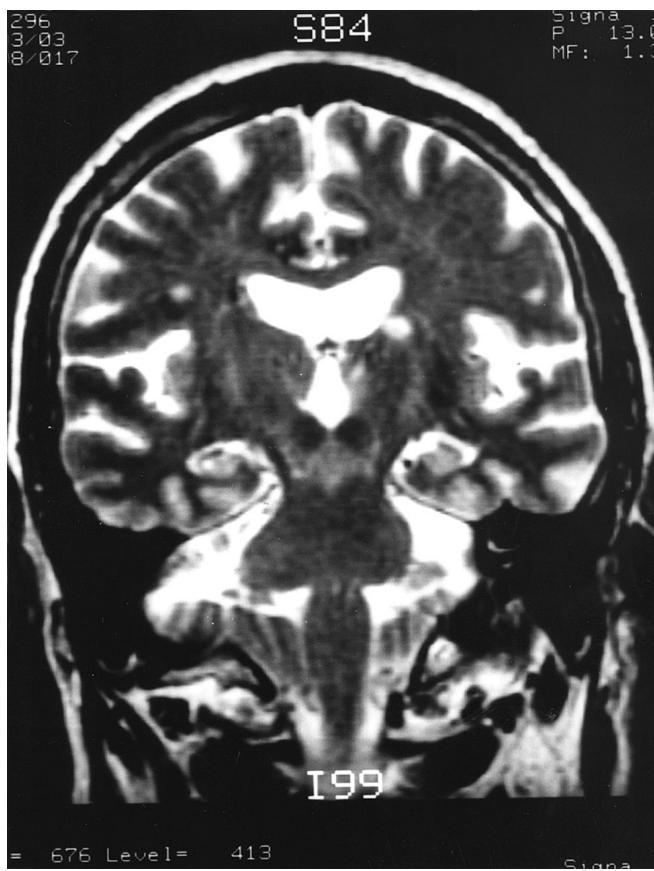


Fig. 3 Patient 3: MRI obtained 10 months after stroke, showing an isolated infarct circumscribed to the inferior part of left capsular genu

spontaneous speech and decreased willingness to start her daily routines, although she remained independent in the activities of daily life. CT showed an infarct on the inferior part of the genu of the right internal capsule (Fig. 4). On the first evaluation she rated high on the dementia scale (5 points), but neuropsychological tests showed only a moderate impairment in memory and temporal orientation. She complained of irritability and memory defects affecting some of her household activities such as cooking and shopping. On the second evaluation 12 months after the stroke she had improved on her functional activities and showed no cognitive impairment or emotional complaints.

In summary (Tables 2, 3), three of these four patients had infarcts on the inferior genu of the left internal capsule and suffered similar disturbances in the acute phase, consisting of disorientation, language and memory impairment, and behavioral changes. The patient with an infarct on the right internal capsule genu showed behavioral changes and memory impairment. Although three patients had deficits in one or more cognitive domains on the first neuropsychology assessment, none was demented. All patients had improved on the second examination performed at least 12 months after the stroke. A moderate memory



Fig. 4 Patient 4: CT obtained in 48 h, showing an infarct on inferior part of the right internal capsular genu

impairment prevailed in two cases (patient 2), along with a moderate verbal comprehension deficit (patient 1).

Discussion

All four patients with inferior internal capsular genu infarction displayed either memory loss, language deficits, apathy, or other behavioral changes on the first examination, but none fulfilled the dementia criteria. Twelve months after the stroke only two showed persisting moderate focal deficits in language comprehension and memory while two recovered. Our investigation was handicapped by two factors: (a) Although we used a comprehensive neuropsychological battery, complex tests assessing executive functions such as the Stroop [28] and Wisconsin Card Sorting Test [19] could not be used because normative data on the Portuguese population are lacking. (b) Although patients with multiple lesions on CT were excluded, and infarcts on CT had a similar location to that in cases of inferior capsular genu infarct as previously reported [30], MRI was performed in only one of our patients.

The capsular genu is supplied by perforating arteries that arise from the apex of the internal carotid or by ante-

rior cerebral artery branches [17]. The lower part is also supplied by anterior choroidal artery branches [30]. Various clinical features may result, depending on the upper or lower involvement of the capsular genu [7]. Infarcts of the inferior part of the internal capsular genu can disturb memory and executive functions, in particular initiative, and if located on the dominant hemisphere they produce language disturbances [1, 23, 24, 30], as confirmed in the present series. These clinical features have some similarity to those found following frontal lobe dysfunction and anterior or dorsomedial thalamic infarct, indicating that these anatomical structures are included in the same functional networks. A strategic infarct in the region of the inferior genu causes interruption of the inferior and anterior thalamic peduncles, thus determining a clinical profile similar to those caused by thalamic infarct. Memory impairment, language disturbances, and defects in executing functions associated with anterior and dorsomedial thalamic infarcts have been well described [8, 9, 18]. Damage to the anterior thalamic peduncle that connects the dorsomedial thalamic nuclei with the anteromedial frontal cortex is the most probable anatomical basis for diminished initiative and abulia. Fibers projecting from the anterior thalamic nucleus to the cingulum and to the subiculum must pass through the internal capsule and corona radiata [31]. The mediodorsal thalamic nucleus, subcallosal area, and amygdala are interconnected via the inferior thalamic peduncle, ventral amygdalofugal pathway, and bandeletta diagonalis. Amnesia may therefore result from basolateral limbic system disconnection [24, 27]. Language is subserved by multiple interconnected cortical subcortical neural networks including a prefrontal cortex–striatum–ventral anterior thalamus network for articulation and language production, a pulvinar–temporoparietal cortex–caudate nucleus network for auditory comprehension and a cingulum–supplementary motor area–striatum–ventral anterior thalamus network for speech production [12]. Left

inferior internal capsular infarct can damage the reciprocal connection between the prefrontal cortex, striatum, and ventral anterior part of the thalamus as well as between the temporoparietal cortex and the caudate nucleus.

Cognitive and behavioral disturbances produced by a single lesion confined to the inferior capsular genu can be due to several mechanisms, such as cortical hypoperfusion related to the internal carotid or middle cerebral artery occlusion, remote cortical metabolic depression or functional interruption. None of our patients had carotid occlusion or severe stenosis. Metter et al. [25] studied a patient with multiple subcortical infarcts, including one located in the left internal capsule genu. Tatemichi et al. [30] used single photon emission computed tomography in three patients and described hypoperfusion in superomedial and infrolateral frontal regions in one patient who had a small infarct in the left capsular genu area.

While unilateral polar or tuberothalamic infarcts may cause abulia, apathy, and amnesia clearing usually in the chronic phase, bilateral paramedian thalamic infarcts may lead to a dementia syndrome [5, 6, 20, 29]. In our four patients the acute mental and behavioral changes improved within 3–12 months, confirming that these disconnection or cortical inactivation mechanisms are not permanent. Gradual recovery of initial hypometabolism upon unilateral thalamic infarcts has been reported by several authors [3, 13]. The mechanism underlying this improvement may indicate recovery of cortical metabolic activity, contralateral compensation, or establishment of ipsilateral alternative pathways.

The series of patients presented here points out the importance of considering time from onset in vascular dementia diagnosis. Current criteria establish a 3-month interval between stroke and the assessment of cognitive impairment. However, serial evaluation is crucial for establishing a reliable long-term prognosis.

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