

Speech Disturbances in Presenile Dementia Related to Local Cerebral Blood Flow Abnormalities in the Dominant Hemisphere

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Ten female patients, age 50-70 years, suffering from presenile dementia and showing signs of defective speech function were analyzed. All patients underwent measurements of regional cerebral blood flow (rCBF) by the xenon clearance technique using a 32-detector piece of equipment, and all showed a marked reduction of the hemisphere mean blood flow level. In addition, regional decreases of blood flow of the gray matter was demonstrated. Patients with a marked reduction in the temporo-parieto-occipital regions showed signs of receptive aphasia including alexia and agraphia. Patients with a marked frontal reduction showed signs of expressive aphasia of various types including stereotyped language, voluble speech, echolalia, and mutism in later stages. The results give further support to our previous conclusion that subsymptoms of presenile dementia, apparently also speech disturbances, can be related to local degenerative changes in the brain, which in their turn are accompanied by local reductions of the blood flow of the gray matter. There is pathoanatomical evidence to support this conclusion.

INTRODUCTION

Speech disturbance is a frequent symptom in organic dementia. In *presenile* dementia such symptoms have been related to the localization of the degenerative changes of the cerebral neurons in post mortem examinations (Sjögren, Sjögren, & Lindgren, 1952; Mansvelt, 1954; McMenemy, 1963). On the whole, however, these studies have not established that the degenerative brain changes have a distribution to be expected from the vast literature on the morphological basis of speech disturbances (Nielsen, 1947; Critchley, 1953; Brain, 1961; Luria, 1966, 1970, 1973).

With the 133-xenon intraarterial technique for regional cerebral blood flow (rCBF) measurements (Lassen & Ingvar, 1972) it is possible to

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measure the functional level of mainly the lateral structures of one hemisphere. In presenile dementia it has been shown that various rCBF parameters show a reduction which is most marked in those regions in which the cortical degenerative changes are pronounced (Brun, Gustafson, & Ingvar, 1975), and hence that the rCBF pattern *in vivo* reflects the distribution of the neuronal degeneration.

The present investigation includes 10 presenile patients with symptoms of aphasia in which the rCBF was measured in the dominant hemisphere. The purpose was to relate the rCBF findings to symptoms of aphasia, i.e., to investigate whether speech disturbances, like other subsymptoms in organic dementia, show a relationship to a reduced functional level, i.e., to low rCBF values in certain brain regions (Gustafson & Risberg, 1974; Gustafson & Hagberg, 1975; Hagberg & Ingvar, 1976).

MATERIALS AND METHODS

Ten females with speech disturbances were selected from a group of fifty presenile patients described elsewhere (Ingvar & Gustafson, 1970; Gustafson & Risberg, 1974). None of them had abused alcohol or drugs, had chronic psychosis, endogenous intoxications, severe head injuries, or major strokes with gross neurological symptoms. The age of the patients ranged from 59 to 70 years and the duration of symptoms from 4 to 8 years. The clinical diagnoses were Alzheimer's disease in seven cases, and diffuse cortical atrophy with frontotemporal predominance, probably Pick's disease, in three cases.

Clinical Investigations

All patients went through complete somatic and neurologic examination including EEG and neuroradiological studies (see case histories below).

Psychiatric and Psychometric Investigations

The psychiatric investigation of the patients was performed according to a formalized rating scale for symptoms of mental dysfunction, emotional disturbances, and behavior changes in dementia. The psychiatric rating, which after the first investigation was repeated at regular intervals, has been described elsewhere (Gustafson, 1975).

The patients were tested with a conventional battery for cognitive deficits. It included tests for verbal performance, immediate memory, logic-inductive ability, and spatial ability. The word list, paired associates (Cronholm & Molander, 1957), and Kohs' block (Matarazzo & Wechsler, 1958) were scored in stanine points (mean = 5, $SD = 2$) and memory for design (Graham & Kendall, 1960) in three categories, "reproduction," "copy," and "cannot copy," the last category being equated with constructional apraxia.

Examination for aphasia was made according to Eisenson (1954) in a slightly modified version, and in this context the evaluation of verbal performance is reported upon. Following Weisenberg and McBride (1935), Eisenson (1954), Lhermitte and Gautier (1969), and Luria (1973) the speech analysis was divided into two major lines, related to expressive and receptive disturbances.

Expressive disturbances were examined with items of successively increasing complexity, starting with verbal repetition of numbers, words, and sentences. Then items followed for automatic speech (counting, enumeration of the alphabet, the days of the week, and the months), naming of body parts, real objects, and on the conceptual level, simple word

finding, sentence completion, opposites, and similarities (abstract word finding). Care was taken not to include aspects in the evaluation other than just the ability for expressive verbal communication.

Receptive disturbances were likewise examined at levels of increasing complexity. *Simple* comprehension required an adequate response to simple propositions ("Sit down, please"; "Point at your nose") and simple questions ("What do people wear on their heads?"). The latter type of items was followed by multiple-choice answers suggested verbally to the patients. For evaluating *complex* comprehension a paragraph was read to the patient, and he was then questioned about its content. Also here care was taken to avoid including in the evaluation things other than comprehension of verbal communication.

The following further aphasia items were made the object of special rating:

Dysarthria: indistinct, slurred speech.

Logorrhea: rapid, voluble speech.

Echolalia: meaningless imitation and repetition of the speech of other people.

Mutism: absence of spontaneous speech.

Stereotyped speech: frequent, unwarranted repetition of phrases and words.

Verbal perservation: involuntary continuation or repetition of phrases and sentences related to preceding questions or topics.

Emotional speech retained: inability to give an ordinary understandable verbal contact except when provoked, or in effect, a retention of simple, emotionally loaded expressions.

Pharaphasia: incorrect substitution of words or parts of them.

Jargon aphasia: fluent speech consisting of a mixture of neologistic, paraphasic, and appropriate words.

The symptoms of aphasia were related as absent (0), present to a slight amount (+), and definitely present (++) .

In addition, the patients were rated as to:

Recent memory: memory for events during the past 6 months.

Remote memory: memory for previous events from childhood and later up to the last year.

Momentary confabulation: the tendency to hide memory failure and to fill the memory lacunes with false statements ("Verlegenheits-Konfabulation," "confabulation of embarrassment"; Bonhoeffer, 1901, 1904; Berlyne, 1972).

Fantastic confabulation: spontaneous fabrication of adventurous, fantastic experiences.

The rCBF Technique

The rCBF was determined *at rest* (i.e., with silence in the laboratory and the patient wearing eye pads) by means of the intra-arterial-133-xenon injection technique using a computer-operated 32-detector piece of equipment (Ingvar & Gustafson, 1970; Sveinsdottir, Torlöf, Risberg, Ingvar, & Lassen, 1971). The theoretical background and the clinical application of this method have been described elsewhere (Lassen, Høedt-Rasmussen, Sørensen, Skinhøj, Crongvist, Bodforss, & Ingvar, 1963; Sveinsdottir et al., 1971; Lassen & Ingvar, 1972; Risberg & Ingvar, 1973). By this method the level of the blood flow (function) is measured mainly in the lateral part of one hemisphere. Subcortical and medial parts of the hemisphere are seen less well by the detectors due to tissue absorption. All the present patients were measured in the left (dominant) hemisphere with the 32-detector system. The positions of the detectors were localized on a lateral skull X ray. The blood flow parameter of main interest in the present context is f_{int} , calculated from the initial slope of the clearance curves. This parameter is mainly determined by the level of activity of the gray matter.

RESULTS

General Findings

At the time of the rCBF study, all 10 patients showed signs of advanced intellectual deterioration. Their principal symptoms and psychometric performance are summarized in Table 1.

TABLE 1
AGE PARAMETERS, CLINICAL SYMPTOMS, COGNITIVE FUNCTIONS, AND SPEECH ABNORMALITIES IN 10 PATIENTS WITH PRESENILE DEMENTIA

Case No.	Age (years)	Duration (years)	Clinical findings	Cognitive functions ^a	Speech abnormalities
1 U.P.	60	8	Slightly euphoric but preserved insight Bewildered, confused Recent memory strongly reduced Remote memory reduced Slight momentary confabulation	Test: V 1 st. M_V 0 I 0 M_S cannot copy Agraphia, alexia Acalculia Apraxia, constructional	Expressive: sentence completion, abstract word finding Receptive: comprehension of complex meaning
2 J.K.	62	4	Completely disorientated Aspontaneous Slow, stiff gait Facial masking and coarse manual tremor Recent memory strongly reduced Remote memory moderately reduced Momentary confabulation Silent, sometimes indistinct speech with stereotyped phrases	Test: V 0 M_V 0 I 0 M_S copy Acalculia Apraxia, ideomotor Right-left disorientation Agnosia, tactile	Expressive: abstract word finding Receptive: slightly disturbed complex comprehension
3 T.Q.	62	6	Restless, irritable Confused, perseverating Emotional labile Facial masking Recent memory strongly reduced Remote memory moderately affected Slow, slurred speech	Test: V 1 st. M_V 0 I 0 M_S copy Acalculia Agnosia, auditive	Expressive: naming Receptive: comprehension of complex meaning
4 F.G.	63	4	Restless Disorientation as to time Easily tired Slightly euphoric and emotionally labile Recent memory strongly reduced Remote memory moderately reduced Slow, indistinct speech with stereotyped fragmented phrases and words	Test: V 1 st. M_V 1 st. I 0 M_S reproduces Agraphia, ideational and motoric Acalculia Apraxia, dressing	Expressive: naming, sentence completion, abstract word finding Receptive: slightly disturbed complex comprehension

TABLE 1 (Continued)

Case No.	Age (years)	Duration (years)	Clinical findings	Cognitive functions ^a	Speech abnormalities
5 H.Q.	59	9	Confused, bewildered Anxiously restless Emotional labile Recent and remote memory strongly reduced Slight momentary confabulation	Test: $V \emptyset$ $M_V \emptyset$ $I \emptyset$ M_S cannot copy Agraphia Alexia Acalculia Apraxia, constructional Agnosia, auditive	Expressive: automatic speech, naming, sentence completion, abstract word finding Receptive: comprehension of complex meaning
6 K.F.	64	7	Anxiously restless Completely disorientated Irritable, emotionally labile Facial grimacing Severe global amnesia Slight momentary confabulation Slurred, "stuttering" speech Can recognize familiar voices	Test: $V \emptyset$ $M_V \emptyset$ $I \emptyset$ $M_S \emptyset$ Agraphia Alexia Acalculia Apraxia, ideomotor and constructional Right-left disorientation Agnosia, general	Expressive: repetitive, automatic, naming, sentence completion, abstract word finding Receptive: disturbance of complex comprehension
7 H.H.	70	7	(1967) Euphoria Logorrhea, slight dysarthria Recent memory severely reduced Remote memory preserved Fantastic confabulation (1971) Akinesia Amimia Mutism Spells of crying Seems to understand simple comments	Test: $V \emptyset$ $M_V \emptyset$ $I \emptyset$ M_S cannot copy Agraphia Apraxia, ideomotor and constructional Agnosia, tactile Not testable	Expressive: naming, sentence completion, abstract word finding Not testable
8 H.K.	60	9	(1969) Euphoria, bulemia Hyperorality Severe general amnesia Fantastic confabulation Volatile, stereotyped speech (1972) Restless, amimia No spontaneous speech, but echolalia and echopraxia Perseverating, stereotyped writing Some simple practical abilities retained	Test: $V \emptyset$ $M_V \emptyset$ $I \emptyset$ M_S cannot copy Agraphia, ideational Acalculia Agnosia, visual Not testable	Expressive: repetitive, automatic, naming, sentence completion, abstract word finding Receptive: simple and complex comprehension Not testable

TABLE 1 (Continued)

Case No.	Age (years)	Duration (years)	Clinical findings	Cognitive functions ^a	Speech abnormalities			
9 H.O.	50	5	(1970)					
			Restlessly walking around	Test: V 0 M_v 0	Expressive: repetitive, automatic, naming, sentence completion, abstract word finding			
			Completely disorientated	I 0				
			Total emotional indifference	M_s copy	Receptive: simple and complex comprehension			
			Global amnesia	Agraphia, ideational Acalculia				
			No verbal contact but preserved simple utterances	Apraxia, ideomotor Agnosia, general				
			(1971)					
			Slight leftsided hemiparesis	Not testable	Not testable			
			Aspontaneous, agitated Amimia					
			Hyperorality					
			Bulimia					
			Anarthria					
			10 B.D.	63	8	Euphoric, restless	Test: V \emptyset	Expressive: automatic, naming, sentence completion, abstract word finding
						Recent and remote memory severely reduced	M_v \emptyset I \emptyset M_s cannot copy	
Voluble, stereotyped speech	Agraphia	Receptive: simple and complex comprehension						
Paraphasic, neologistic jargon	Alexia Acalculia Apraxia, general Agnosia, general							

^a Symbols: V = verbal function, M_v = verbal immediate memory, I = logic-inductive function, M_s = spatial immediate memory or spatial function. Points are given in stanine, st., with $m = 5.0$ and $SD = 2.0$. 0 = adequate attempt but failure in performance; \emptyset = not capable of attempt.

According to our previous analyses (Gustafson & Hagberg, 1975; Hagberg & Ingvar, 1976), the patients could be classified as having either: a general intellectual and verbal reduction including anomia, acalculia, and disturbed but retained spatial ability (group C 4 according to Hagberg & Ingvar, 1976); or a general intellectual and verbal reduction with aphasia, agnosia, and apraxia, as well as a distorted spatial ability (group C 5). All patients showed memory failure, verbal perseveration, disorientation, and impairment of thinking, speech, and motor behavior. They also showed personality alterations with emotional shallowness, or indifference, euphoria, and in some cases, uninhibited behavior. Emotional lability was common with easily provoked catastrophic reactions or spells of aggressive behavior. The symptoms of speech disturbances are presented in Table 2. Apart from symptoms of dementia including speech disturbance, none of the 10 patients showed other neurological abnormalities, except case 9 who showed a slight left-sided hemiparesis.

The mean rCBF parameters of the 10 patients together with values from

TABLE 2
SYMPTOMS OF SPEECH DISTURBANCE

Patient No. Patient code	1 U.P.	2 J.K.	3 T.Q.	4 F.G.	5 H.Q.	6 K.F.	7 H.H.	8 H.K.	9 H.O.	10 B.D.
Expressive functions										
Repetitive	-	-	-	-	-	++		++	++ ^{1/}	-
Automatic	-	-	-	-	+	++		++	++ ^{1/}	++
Naming	-	-	++	++	++	++	++	++	++ ^{1/}	++
Sentence completion										
Abstract word finding	++	++	-	++	++	++	++	++	++ ^{1/}	++
Logorrhea	-	-	-	-	-	-	++ ^{1/}	++ ^{1/}	-	++
Echolalia	-	-	-	-	-	-	-	++	-	+
Mutism	-	-	-	-	-	-	++	++	++	-
Stereotyped speech	-	-	-	+	-	+	-	-	-	++
Preserved emotional speech	-	-	-	-	-	-	-	++	-	++
Dysarthria	+	+	++	+	-	+	++ ^{1/}	-		++
Receptive functions										
Simple	-	-	-	-	+	-		++	++ ^{1/}	++
Complex	++	+	++	+	++	++		++	++ ^{1/}	++

Symbols: -, absence of symptom; +, slight or intermittent presence of the symptom; ++, presence of the symptom; 1/, evaluation refers to stage prior to the final mutistic one.

a control group are shown in Table 3. The significant differences are easily seen.

Individual Findings

The 10 patients will be described individually with regard to symptoms, test performance, and rCBF measurements. The rCBF distribution refers only to f_{init} values (Fig. 1).

TABLE 3
MEAN HEMISPHERE rCBF VALUES IN CONTROLS AND IN
10 PATIENTS WITH PRESENILE DEMENTIA

Patients	No.	Age (years)	Sex	PCO ₂	f_{init}	f_{10}	f_g	g%
Patients with pre- senile dementia	10	62 ± 5	10 F	41 ± 4	35 ± 6	34 ± 5	54 ± 7	43 ± 4
<i>P</i> value (one-tailed <i>t</i> test)					<0.0005	<0.0005	<0.005	<0.001
Control group (Ingvar <i>et al.</i> , 1975)	15	46 ± 5	1 F, 14 M	40 ± 2	47 ± 7	45 ± 4	68 ± 11	49 ± 4

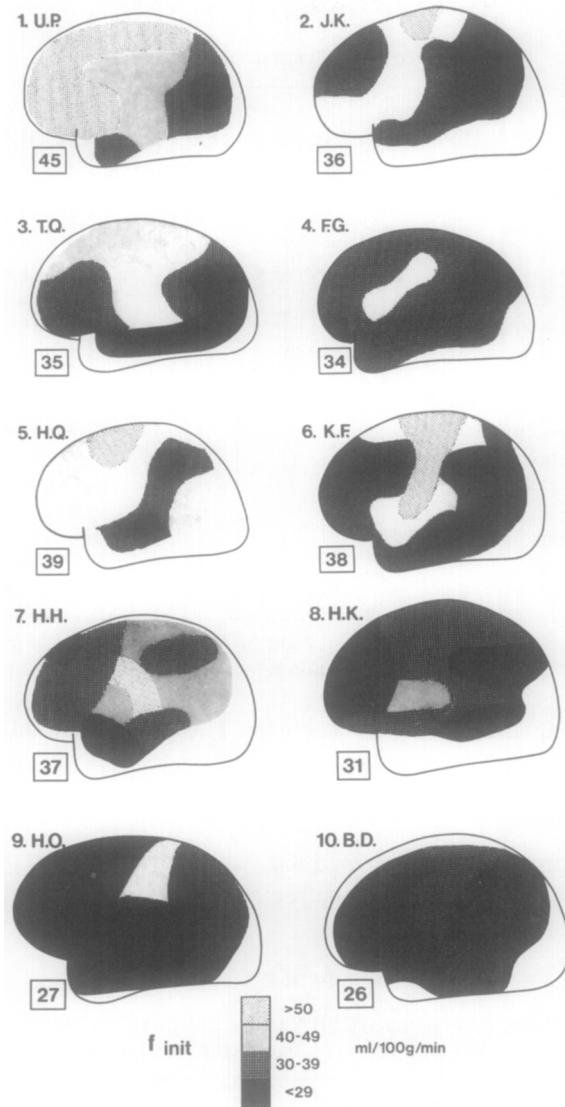


FIG. 1. Regional distribution of the cerebral blood flow in the dominant hemisphere in 10 patients with presenile dementia and speech disturbances. The flow was calculated as f_{init} values in milliliters per 100 g per min (according to the scale at bottom) from the first minutes of each regional clearance curve. Cases 1 through 6 and case 10 were diagnosed as Alzheimer's disease, cases 7, 8 and 9 as Pick's disease.

Case 1 (U.P.). Alzheimer's disease. A 60-year-old female, confused, slightly euphoric, and confabulating, but with relatively preserved insight in her mental dysfunction. Her amnesia was severe, but remote memory was somewhat less affected. She had agraphia, alexia, acalculia, and

constructional apraxia. She spoke spontaneously but with an expressive speech disturbance, affecting the word-finding ability both in sentence completion and in similarities and opposites, as well as receptive disturbance of comprehension of complex meaning. The rCBF reduction strongly affected the postcentral areas with a focal accentuation in the parieto-occipital area. Precentral areas were comparatively spared.

Case 2 (J.K.). Alzheimer's disease. A 62-year-old female, completely disoriented, aspontaneous, and with some symptoms of Parkinson's disease. Immediate and recent memory was markedly defective and remote memory was moderately reduced. She also had acalculia, ideomotor apraxia, right-left disorientation, and tactile agnosia. Her speech was whispering, stereotyped, with some dysarthria and with receptive disturbances for complex meaning, as well as some failure of abstract word finding on the expressive side. The rCBF pattern showed a marked reduction in the temporo-occipital region and to some extent also over the frontal convexity.

Case 3 (T.Q.). Alzheimer's disease. A 62-year-old female, confused, restless, irritable, emotionally labile, and also demonstrating dysarthria and facial masking. Immediate and recent memory was markedly reduced, while remote memory was somewhat better retained. She also manifested acalculia and auditory agnosia. Her speech disturbance affected naming and understanding of complex meaning. The rCBF pattern showed a marked reduction in the lower temporal and parietal region, but also in the frontobasal area.

Case 4 (F.G.). Alzheimer's disease. A 63-year-old female, restless, confused, slightly euphoric, and emotionally labile. Immediate and recent memory was markedly reduced and remote memory was moderately reduced. She had agraphia, acalculia, and dressing apraxia. Her speech was slow, indistinct, with stereotyped phrases and words. Naming, sentence completion, and abstract word finding were impaired and, to some extent, comprehension of complex material. The rCBF measurement showed a marked general reduction most pronounced in the occipital and frontobasal region, sparing the rolandic area.

Case 5 (H.Q.). Alzheimer's disease. A 59-year-old female, completely disoriented, restless, with a global amnesia and slight confabulation. She manifested agraphia, alexia, acalculia, apraxia, and auditory agnosia. She spoke spontaneously and was a good singer. She had a pronounced expressive speech disturbance, which, however, did not affect repetitive speech so much. She could to some extent understand simple meaning. The rCBF was generally reduced, most pronounced in the temporo-parietal region.

Case 6 (K.F.). Alzheimer's disease. A 64-year-old female, anxious, restless, irritable, and completely disoriented. She had a global amnesia with slight momentary confabulation. She also had apraxia, agraphia,

alexia, acalculia, right-left disorientation, and general agnosia. She could, however, recognize some familiar voices. Her speech was slurred and stuttering. She showed an expressive disturbance which was manifested as a disability in naming and in abstract word finding. Automatic speech and simple repetition of figures and sentences were also defective. Her receptive speech disturbance affected comprehension of complex meaning. There was a general rCBF reduction which was most pronounced in temporo-parieto-occipital, as well as in frontal regions.

Case 7 (H.H.). Pick's disease. A 70-year-old female with akinesia, rigidity, extreme paucity of facial expressions (amimia), mutism, and spells of crying. She was on the whole untestable, but gave the impression of understanding simple commands. Four years prior to the study she had been testable. She was then euphoric, talkative, confabulating, with a highly reduced immediate memory. She also manifested agraphia, tactile agnosia, and an expressive speech disturbance affecting naming, sentence completion, and abstract word finding. The rCBF pattern in the latter akinetic stage showed a very marked general reduction, most pronounced in the frontal and temporal (especially anterior temporal) areas.

Case 8 (H.K.). Pick's disease. A 60-year-old female. Three years earlier she was euphoric, logorrheic, confabulating, with global amnesia and a Klüver-Bucy syndrome. Testing revealed a global expressive, as well as receptive, aphasia. At the time of the present rCBF study, the clinical picture had changed and restlessness, amimia, semimutism, and echophenomena were marked. She showed a fluent perseverant, neologistic writing and was not testable anymore. The rCBF measurement showed very low mean hemisphere values, and the flow reduction was most pronounced in the precentral as well as postcentral areas with a relative sparing of the central area in between. Most severely affected were the frontal pole and the posterior temporal and parieto-occipital areas.

Case 9 (H.O.). Pick's disease. A 50-year-old female with a slight left-sided hemiparesis. She was agitated, gave no verbal contact, and was not testable. She also had amimia, hyperorality, and bulemia. One year earlier she had been restless, completely disorientated, and emotionally unresponsive. She showed severe aphasia, but had retained some emotional utterance. In the later mutistic state, the rCBF measurement showed a general reduction, most marked in frontal and temporal regions, somewhat sparing the central (rolandic) region.

Case 10 (B.D.). Alzheimer's disease. A 63-year-old female, euphoric, laughing, disorientated with severe agraphia, alexia, agnosia, and apraxia. She could still walk when given support. Her speech was indistinct, at times voluble, fragmented with a paraphasic neologistic jargon.

She had a severe receptive aphasia. The rCBF measurements showed a marked general reduction, somewhat sparing the rolandic region.

DISCUSSION

First, some facts regarding the rCBF method should be recalled. It is generally accepted that rCBF values reflect the regional level of the cerebral functional activity, i.e., under normal conditions (in absence of tissue anoxia) the flow level varies with the neuronal activity (Ingvar & Lassen, 1975). In dementia the rCBF parameters show a flow decrease when an intellectual deterioration develops (Freyhan, Woodford, & Kety, 1951; Fazekas, Bessman, Cotsonas, & Alman, 1953; Gustafson & Risberg, 1974; Hagberg & Ingvar, 1976). The most distinct clinical correlations concern rCBF parameters determined by the gray matter flow (f_g and f_{init}). Normally at rest structures situated precentrally have a higher flow than postcentral ones (Ingvar & Schwartz, 1974; Ingvar, 1975). During various types of mental activity this resting pattern is changed. Speech and reading activate the cortical speech areas and rolandic regions in the dominant hemisphere (Ingvar & Schwartz, 1974). Abstract thinking gives rise to an increase of the flow in cortical association areas situated frontally as well as in the temporo-parieto-occipital region (Risberg & Ingvar, 1973; Ingvar, Risberg, & Schwartz, 1975). In presenile dementia the flow pattern at rest correlates with clinical and psychometric defects in stages of successive deterioration (Gustafson & Risberg, 1974; Gustafson & Hagberg, 1975; Hagberg & Ingvar, 1976). A good correspondence has been shown between the degree and localization of the pathoanatomical findings and the rCBF values (Brun, Gustafson, & Ingvar, 1975; Gustafson, Brun, & Ingvar, 1976).

The present 10 patients were all severely deteriorated with a marked general intellectual impairment, emotional disturbance, and personality changes. From this spectrum of symptoms, we have selected the speech disturbances as the main object of our study. Our previous analyses of the presenile and other demented patients (Gustafson & Hagberg, 1975; Hagberg & Ingvar, 1976) have confirmed that verbal performance in presenile dementia is more resistant to deterioration than other intellectual functions. This observation underlies the concept of "differential decline," originally suggested by Babcock (1930) and also discussed by Yates (1954), Wechsler (1958), Orme, Lee, & Smith (1964), and others. Symptoms of speech dysfunction may thus be conceived as late manifestation in organic dementia.

The present 10 patients formed four subgroups with principally different rCBF patterns. Cases 1, 2, 3, and 4, with Alzheimer's disease,

showed the most pronounced flow reduction in the *temporo-occipital region*. The precentral area was better preserved, except in cases 3 and 4 who both had a frontobasal diminution. All four patients showed signs of *receptive* speech disturbance, especially for complex material. The *expressive* aphasia was most marked in patients 3 (naming) and 4 (naming, abstract word finding, and stereotyped speech). The common symptoms of receptive aphasia thus appear related to the temporo-occipital flow reduction, while the expressive disturbances of cases 3 and 4 appear related to the low frontobasal or frontotemporal flow.

It should also be noted that all four patients (1-4) had a severe reduction of immediate memory. However, they did not show any signs of logorrhea, echolalia, or mutism, a finding compatible with the relatively well-preserved flow in the precentral region.

Two patients, cases 5 and 6, with Alzheimer's disease, also had low flows postcentrally as in cases 1-4, but the reduction affected mainly the *temporoparietal region*. Patient 6 had, in addition, a frontal flow reduction. Both patients had *receptive* speech disturbance for comprehension of complex meaning. In addition, both had more severe disturbance of *expressive* speech, even including automatic speech and, for case 6, also simple repetition. The common regional disturbance in cases 5 and 6 was found within temporoparietal regions, most likely involving Wernicke's area. Similar to patient 4 in the preceding group, patient 6 also manifested stereotyped speech. The marked expressive disturbance as well as the stereotyped speech of these two patients thus appear related to the frontal flow reduction.

Two patients, case 7 with Alzheimer's disease and case 8 with Pick's disease, showed the most pronounced flow reduction within the *frontal, temporal, and parietal regions* (in case 8, also in the occipital region). Both patients had a fairly well-preserved flow in the central (rolandic) region. They showed a severe *expressive* aphasia which had developed into mutism at the time of the flow study. They also showed some receptive defects, which, however, were less marked. Prior to the mutistic state, both cases had shown euphoria and logorrhea. Case 8 later on developed echophenomena and a fluent perseverative partly neologistic writing. The expressive speech disturbance in these two patients, including the early manifestation of signs of disinhibition, appears to be a part of a general failure of programming and regulation of behavior (Bay, 1962; Luria, 1973). Such symptoms of frontal lobe deficiency are in good agreement with the flow reduction recorded in precentral regions in these two patients.

Finally, in case 9 with Pick's disease and case 10 with Alzheimer's disease, there was a severe general flow reduction, sparing the central

(rolandic) region. Both patients showed *global aphasia*. Case 9 had no spontaneous speech, but showed restlessness and hyperorality. Case 10 had a voluble, paraphasic, incomprehensible jargon. In both patients the speech produced had lost its meaning, and speech programming and regulation had disappeared almost completely. This language dissolution thus included disturbances at all levels of speech formation, a fact to be expected from the severe general flow reduction. The speech rudiments still left in cases 9 and 10 appeared autonomous, mediated by the relatively well preserved, but badly controlled sensory-motor region.

In summary, the present 10 cases of advanced presenile dementia showed a marked agreement between their symptoms of speech defects and the distribution and severity of their rCBF abnormalities. Many of the details of the individual case histories support classical concepts about the morphological basis of expressive and receptive forms of aphasia. There is thus reason to conclude that speech defects in organic dementia depend upon degenerative brain changes, which have the same localization, in principle, as have other brain lesions leading to symptoms of aphasia. However, the present patients showed general signs of severe global speech defects, i.e., strictly focal types of aphasia were not encountered. This is to be expected since the underlying degenerative disorders were of a diffuse type. However, in all patients there were superimposed "focal" aspects of the aphasic symptoms, which as shown could be related in a meaningful way to the distribution of the rCBF abnormalities.

CONCLUDING REMARKS

The present study forms part of a prospective, longitudinal investigation of the cerebral circulation in patients with presenile dementia. Significant correlations have been found between the subsymptoms of dementia and the rCBF values and their distribution (Ingvar & Gustafson, 1970; Gustafson & Risberg, 1974; Gustafson & Hagberg, 1975; Hagberg & Ingvar, 1976). The present detailed analysis of 10 of our patients shows first that verbal ability fails only when there is a marked general flow reduction in the dominant hemisphere. In addition, we have found a relationship between specific speech defects and the distribution of the rCBF abnormalities in the dominant hemisphere. When *receptive* disturbances dominated, the most marked flow reduction was found in post-central regions, especially in the temporoparietal. When *expressive* speech disturbances dominated, marked frontal and anterior temporal flow reductions were found, especially when there was a failure of speech regulation. Failure of speech regulation may thus be considered as a part

of a frontal lobe syndrome. Other forms of speech disturbance, such as logorrhea, paraphasic jargon, and neologistic writing, appeared to be of an intermediary type. Such symptoms were found in patients with marked pre-, as well as postcentral flow reductions in combination with a relatively well-preserved flow in rolandic regions.

It should be emphasized that the present 10 patients did not show signs of classical "focal" aphasia of clear-cut expressive (Broca), receptive (Wernicke), or other types. Patients with such forms of aphasia show local rCBF abnormalities which in many respects confirm classical pathoanatomical findings, as shown by Kohlmeyer (1975a, 1975b; cf. Larsen, Skinhøj, & Endo, 1976).

The present findings give general support to the classical concepts concerning speech and brain functions. They stress the fact that speech has a multiregional determination, and this may explain the relative resistance of speech functions to the diffuse progressive degenerative brain changes which underlie the intellectual deterioration in organic dementia. The total mean level of cerebral blood flow, representing the general level of functional brain activity, does not determine the occurrence of speech disturbances in dementia. It is the regional distribution of the flow abnormalities which relates in a meaningful way to the type of speech defect. However, both general and regional flow reduction correspond to degenerative changes of the neurons as shown elsewhere (Brun *et al.*, 1975; Gustafson *et al.*, 1976). Hence, it can be inferred that speech disturbances in presenile dementia, like other subsymptoms of the disorder, reflect the distribution of the underlying degenerative changes in the brain.

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