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Computed tomography findings in senile dementia and normal aging

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SUMMARY Computed tomography (CT) findings in 57 patients with senile dementia of Alzheimer type (SDAT), 19 patients with multi-infarct dementia and 85 controls of similar age and sex were studied. The SDAT patients differed from the controls in ventricular dilatation, frontal horn index, cella media index and the width of the third ventricle, and also in the index of cortical atrophy. Even the least severely demented SDAT patients differed from the controls. In the SDAT group with the increasing degree of intellectual impairment the ventricular dilatation increased, but cortical atrophy did not correlate with the psychological test score. The multi-infarct dementia patients differed from the controls in all CT variables including local changes. The SDAT patients had a more marked ventricular dilatation than the multi-infarct dementia patients. The multi-infarct dementia patients had more frequently local changes than the SDAT patients. In the control group age correlated with ventricular dilatation, and the lower test scores correlated with cortical atrophy in the left temporal region.

Computed tomography (CT) can show cerebral atrophy by demonstrating increased ventricular size and sulcal widening, and has largely replaced pneumoencephalography (PEG) as a safe non-invasive technique for investigation of dementia.[1-3] CT is also excellent to exclude vascular and expansive lesions.[4 5] The value of CT in evaluating brain atrophy in elderly people is diminished by the fact that in normal aging ventricles dilatate with increasing age.[6 7] Barron *et al*[8] studied ventricular size during aging and found a gradual progressive increase in ventricular size from first to the sixth decade followed by a dramatic increase in the eighth and ninth decades. The range of normal ventricular size was relatively wider in the eighth and ninth decades than in the first seven.

The relationship between cerebral atrophy and the intellectual impairment had been widely discussed. Roberts and Caird,[3] Roberts *et al*[9] demonstrated a significant association of intellectual impairment with ventricular area on CT scan but not with the width of cortical sulci; the same was reported by Stefoski *et al*[10] and by Jacoby and Levy.[11] De Leon *et al*[12] suggested a definite relationship between changes seen on CT and cognitive function in senile dementia of Alzheimer type (SDAT), this applies to both sulcal and ventricular changes, but the relationship is more consistent for the latter.

The purpose of the present study is to evaluate CT findings in SDAT, multi-infarct dementia (MID) and normal elderly people. The relationship between CT changes and intellectual impairment is also studied.

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Patients and methods

Patients

Eighty patients with a presumptive diagnosis of senile or arteriosclerotic dementia were studied. The patients were collected from the Geriatric Departments of Harjamäki and Julkula Mental Hospitals, the Rehabilitation Department of Vaajasalo Hospital and the nursing homes for the elderly of Kuopio and Siilinjärvi. The patients were examined personally at the Neurological Department of Kuopio University Hospital. The examination included clinical and neurological investigation, laboratory tests to exclude metabolic, endocrinic, infectious and nutritional disorders, cerebrospinal fluid, radiography of the skull and the chest, EEG and CT. Thus symptomatic causes of dementia were excluded. In four patients dementia could not be confirmed even by a repeated psychological examination and they were excluded. The diagnosis of SDAT and MID was based on clinical criteria. The diagnosis was verified at autopsy so far in five cases. The SDAT patients had a history of

progressive mental deterioration, disorientation, failure of memory and intellect. Differentiation between SDAT and MID was made by using the Ischemic Score.[13] Seventy-six patients were included, 57 SDAT patients and 19 MID patients. The patients were 56 females and 20 males, mean age 77 ± 6 years, with onset of the disease at age of 72 ± 7 years and duration of the disease 5·4 ± 4·1 years.

Controls

Thirty-two of the controls were voluntary inpatients from the same nursing homes as were some of the dementia patients. Further, a random sample of the population aged over 65 years in Kuopio and Siilinjärvi was taken and 53 control subjects living at home were collected. The controls were also examined personally and they underwent the same investigations as the dementia patients, but the cerebrospinal fluid was not examined. Eighty-five control subjects had no neurological disease or dementia. The controls were 68 females and 23 males with mean age 75 ± 7 years.

Psychological examination

The intellectual status of the patients and the controls was examined by an experienced psychologist using a test score including the following: personal and up-to-date knowledge, orientation, praxias of hand, receptive speech, expressive speech, memory, general reasoning: arithmetic (Luria), similarities (WAIS), comprehension (WAIS).[14] The total points varied from 0, representing a complete failure, to 102 representing a full score in the battery. The SDAT patients were divided into three groups of varying severity. The most severely demented patients were not capable of even taking part in the test (SDAT 3, n = 21). An intermediate group (SDAT 2, n = 18) obtained 1-20 points in the test. The least severely affected patients (SDAT 1, n = 18) obtained 21 or more in the test. Activities of daily living (ADL) were estimated by a rating scale including the following: eating, dressing, personal hygiene, bladder and bowel control, movement capability, recognition of surroundings and occurrence of psychiatric symptoms. The points varied from 0 reflecting an extreme incapacity to 30 representing a fully preserved capacity.

CT examination

All CT examinations were made by third generation, rotate-fan beam scanner (Somatom 2, Siemens). Image matrix was 256 × 256. Scan parameters were: time 10 seconds, slice thickness 8 mm, 125 kv, 230 mAs. Contrast enhancement was not used in any case. The level of the first scan was at the base of skull through the fourth ventricle parallel to orbotomeatal line. The number of scans per patient was 8-12 without overlapping. Patient history or other clinical data were not known during measurement. The precision of measurement was high, because it was made from floppy discettes by an electronic measuring program which gave all linear dimensions straight in millimetres. Reliability of measurement was tested with a small random sample of cases (15 patients or controls) and was found to be high (reliability coefficient over r = 0·96 in all parameters). We used following parameters (see figure):

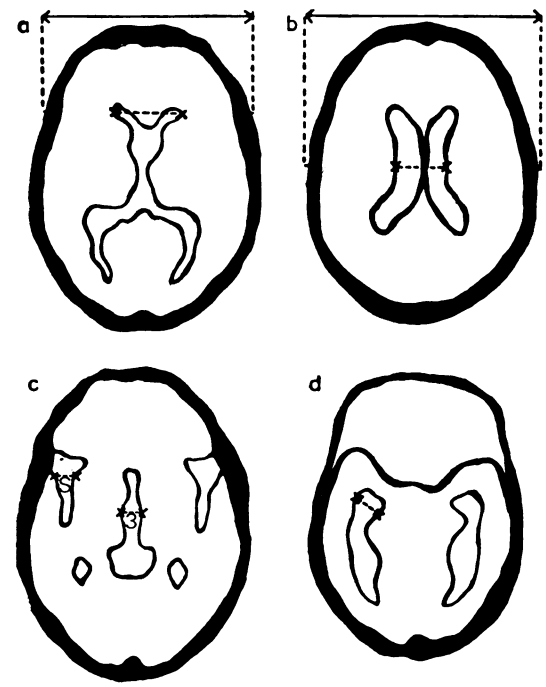

Figure *CT scan sections used for various measurements in this study. (a) Frontal horn index = ratio of maximal width of frontal horn and respective maximal width of skull, (b) Cella media index = ratio of minimal width of lateral ventricles in cella media region and respective width of outer skull table, (c) Maximal width of the third ventricle (3), temporal cortex = maximal width of Sylvian fissure at insula (s), (d) Temporal horn = maximal width of temporal horn tips.*

(1) FHI = frontal horn index = ratio of maximal width of frontal horns and respective maximal width of skull, (2) CMI = cell media index = ratio of minimal width of lateral ventricles in cella media region and respective width of outer skull table, (3) III ventricle = maximal width of the third ventricle, (4) Temporal horns = maximal width of temporal horn tips on both sides, (5) Temporal cortex = maximal width of Sylvian fissure at insula on both sides, (6) CI = cortical index = the mean of four largest sulci from the highest cut.

Parameters 1-4 measured central atrophy. Parameters 5-6 measured cortical atrophy. All local atrophies were noted.

Statistical analysis

Statistical analysis of data was made by using a computer. Significances of the differences were determined by using the Chi-square test and the analysis of variance and

correlations were determined by using Pearson correlation coefficients.

Results

The parameters of temporal atrophy correlated with each other and also with the width of the third ventricle. The width of the third ventricle correlated with other indexes of ventricular dilatation FHI, and CMI (table 1). The index of cortical atrophy correlated with FHI, CMI and the width of the third ventricle (table 1).

Table 1 *Correlations between indexes of central and cortical atrophy in dementia patients and normal elderly people*

	III	*CI*
FHI*	0·75†	0·26‡
CMI	0·77†	0·31†
III	1·0	0·39†

n = 161.
*FHI = frontal horn index, CMI = cella media index, III = the width of the third ventricle, CI = index of cortical atrophy. Correlations are tested by using Pearson correlation coefficients. †$p < 0.0001$, ‡$p < 0.001$.

The dementia patients differed from the controls in the parameters of temporal atrophy on both sides, the indexes of ventricular dilatation, FHI, CMI, the width of the third ventricle and also in cortical atrophy. There were no differences in local changes suggesting an infarct in the dementia and the control group (table 2).

The SDAT patients also differed from the controls in all CT variables including cortical atrophy except in local changes which were more common in the controls, but the difference was not significant (table 2).

The MID patients differed from the controls in FHI, CMI, the width of the third ventricle and also in cortical atrophy and local changes. A local change was seen in five MID patients (26%) and six control subjects (7%). The SDAT patients had a more marked ventricular dilatation than the MID patients. Local changes were more frequent in the MID group than the SDAT group, only one SDAT patient (1·8%) had a local change while 26% of the MID patients had local changes (table 2).

The SDAT patients were divided into three groups of varying severity and the subgroups were compared with the controls. All the subgroups differed considerably from the controls in the indexes of ventricular dilatation. When the index of cortical atrophy in the SDAT subgroups was compared with the controls the differences were less prominent than those seen in ventricular dilatation (table 3). When the SDAT subgroups were compared with each other, cortical atrophy seemed to be no different between the groups. The least severely demented SDAT patients (SDAT1) did not differ from the intermediate group in any CT variables. SDAT1 group and SDAT2 group differed from the most severely demented patients (SDAT3) in the indexes of ventricular dilatation. In the SDAT group the psychological test score and ADL points correlated with the indexes of ventricular dilatation but not with cortical atrophy (table 4). There was no correlation between age or sex and the CT indexes. The duration of the disease correlated weakly with FHI and CMI (table 4).

In the control group the psychological test score correlated with FHI, CMI and the width of the third ventricle and also with left temporal atrophy and right central temporal atrophy. But no correlation was seen between the test score and the index of cortical atrophy or local lesions (table 5).

Table 2 *Significance of the differences in CT indexes of dementia patients, of patients with senile dementia of Alzheimer type (SDAT) and of patients with multi-infarct dementia (MID) compared with normal elderly people*

	Dementia (n = 76)/controls (n = 85)	*SDAT (n = 57)/controls*	*MID (n = 19)/controls*	*SDAT/MID*
Left ce†	***	***	*	NS
Right ce	***	***	***	NS
Left co	***	***	NS	NS
Right co	***	***	***	NS
FHI	****	****	**	**
CMI	****	****	****	**
III	****	****	***	NS
CI	****	***	****	NS
Infarct	NS	NS	*	***

Significances of the differences between dementia groups and controls are tested by using the analysis of variance in FHI, CMI, III, CI and the chi-square test in the other variables.
†Left ce = left central temporal, left co = left cortical temporal, FHI = frontal horn index, CMI = Cella media index, III = width of the third ventricle, CI = index of cortical atrophy.
****$p < 0.0001$
***$p < 0.001$
**$p < 0.01$
*$p < 0.05$.

Table 3 *Frontal horn index (FHI), cella media index (CMI), width of the third ventricle (III) and index of cortical atrophy (CI) in dementia patients, patients with senile dementia of Alzheimer type (SDAT) of varying severity compared with normal elderly people*

	Controls (n = 85)	*Dementia (n = 76)*	*SDAT 1 (n = 18)*	*SDAT 2 (n = 18)*	*SDAT 3 (n = 21)*
FHI	0·32 ± 0·04	0·38 ± 0·06*	0·36 ± 0·04†	0·38 ± 0·05*	0·44 ± 0·07*
CMI	0·23 ± 0·03	0·29 ± 0·05*	0·28 ± 0·04*	0·28 ± 0·04*	0·32 ± 0·05*
III	9·27 ± 2·71	14·32 ± 3·33*	13·00 ± 2·81*	14·22 ± 3·46*	16·76 ± 3·18*
CI	6·32 ± 1·93	8·11 ± 2·64*	7·46 ± 2·10	8·18 ± 2·32†	7·99 ± 2·89‡

Results are means ± SD. Significance of the differences between dementia groups compared with the controls are tested by using the analysis of variance (including classification for age and sex).
*p < 0·0001
†p < 0·001
‡p < 0·005.

Table 4 *Correlations between CT indexes and psychological test score, ADL points, age, sex and duration of the disease in patients with senile dementia of Alzheimer type*

	Psych test score	*ADL*	*Age*	*Sex*	*Duration of the disease*
FHI†	−0·39***	−0·49***	−0·06	−0·01	+0·23*
CMI	−0·35**	−0·43***	−0·12	−0·08	+0·29*
III	−0·40***	−0·30**	+0·03	−0·05	+0·15
CI	−0·18	−0·14	−0·07	+0·01	+0·10

n = 57.
†FHI = frontal horn index, CMI = cella media index, III = width of the third ventricle, CI = index of cortical atrophy. Correlations are tested by Pearson correlation coefficients.
***p < 0·001
**p < 0·01
*p < 0·05.

Table 5 *Correlation between the psychological test score and the CT variables in normal elderly people*

	Test score (n = 85)	*Test score ⩽ 75/> 75 (n = 21) (n = 64)*
Left ce†	−0·31**	−0·29**
Right ce	−0·27**	−0·22*
Left co	−0·28**	−0·38***
Right co	−0·17	−0·24*
III	−0·24*	−0·30**
FHI	−0·26**	−0·24*
CMI	−0·25**	−0·16
CI	−0·10	−0·09
Infarct	−0·13	−0·17

†Left ce = left central temporal, left co = left cortical temporal, III = width of the third ventricle, FHI = frontal horn index, CMI = cella media index, CI = index of cortical atrophy.
Correlations are tested by using Pearson correlation coefficients.
***p < 0·0001
**p < 0·01
*p < 0·025.

When the controls were divided into two groups according to the psychological test score, the group with 75 or less points in test and the group with 76 or more points in the test, a difference between the groups was seen particularly in left temporal cortical atrophy, and in the indexes of ventricular dilatation, except CMI, but not in the index of cortical atrophy (table 5). In the control group age correlated with CT indexes, FHI r = 0·46, CMI r = 0·38 (p < 0·0001) and CI r = 0·31 (p < 0·01). Sex did not correlate with the CT indexes in the control group.

Discussion

The dementia patients of the present study differed from the controls both in ventricular dilatation and also in cortical atrophy. The same differences were apparent when the SDAT patients, even the least severely demented, were compared with the controls. There was, however, a certain overlapping in the values of dementia patients and normal elderly people in individual cases, particularly in early stages of dementia.

In SDAT ventricular area increased with increasing degree of intellectual impairment while cortical atrophy did not correlate with the psychological test score. This result is in agreement with earlier observations.[3 10 11 15]

Jacoby and Levy[11] have suggested that in normal elderly people a low score in the psychological examination correlates with cortical atrophy. In the present study cortical atrophy in the left temporal region correlated with the low psychological test score. This may be related to asymmetric findings in the left temporal region in EEG which are common in normal elderly people.[16] Clinically cortical atrophy in the left temporal region may be related to

benign senescent forgetfulness.[17]

Though with increasing age the ventricular size increases, according to our results CT is of value when the possibility of dementia is evaluated. Employment of quantitative indexes standardised for age may aid in differentiating cerebral atrophy associated with dementia from that associated with normal aging.[18] If ventricular dilatation is not demonstrable in an elderly person with considerable intellectual impairment, a potentially curable metabolic, toxic, infectious or psychogenic cause of the symptoms should be pursued.[1] According to CT studies on normal and demented old people it is clear that the diagnosis of dementia cannot be based on CT findings, but is always clinical.

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