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Computed Tomographic Density Numbers

A Comparative Study of Patients with Senile Dementia and Normal Elderly Controls

J. COLGAN, M. NAGUIB AND R. LEVY

Cranial computed tomography (CT) scans of 48 patients with senile dementia of the Alzheimer type (SDAT) and 40 normal elderly volunteers were compared. The demented group were found to have significantly larger lateral ventricles assessed planimetrically and by using a linear measure of the ratio of the maximum width of the frontal horns of the lateral ventricles to the maximum intracranial diameter. Attenuation density was computed for 15 brain regions. The demented group did not differ significantly from the normal controls with respect to attenuation density in any of the regions studied.

Reports on computed cranial tomography (CT) generally concur in the finding that patients with senile dementia have larger lateral and third ventricles than normal elderly controls (Jacoby & Levy, 1980; Gado *et al*, 1982). Similarly patients with senile dementia have been shown to have more severe sulcal widening as rated by an experienced neuroradiologist, than normal elderly controls (de Leon *et al*, 1980; Jacoby & Levy, 1980). There is, however, substantial overlap between groups both with respect to estimates of ventricular size and cortical atrophy and were one to make a diagnosis of senile dementia solely on the CT finding then at least 17% of subjects would be misclassified (Jacoby & Levy, 1980).

It is less clear whether patients with senile dementia differ from normal elderly controls with respect to CT attenuation density (Brinkman *et al*, 1981). Some workers including our own group, have reported patients with senile dementia as having lower brain attenuation density than controls (Bondareff & Levy, 1981; Naeser *et al*, 1982), others reported no difference (Wilson *et al*, 1982; Gado *et al*, 1983) and one group found density to increase with the severity of dementia (George *et al*, 1981). Comparison between studies is difficult for several reasons. Different scanners have been used which may not produce comparable density measurements and in one study results obtained using several scanners were amalgamated (Wilson *et al*, 1982). Studies have used differing criteria for subject selection and attenuation density has been computed for regions that are not comparable in site or size.

In view of the conflicting findings concerning CT brain attenuation density in senile dementia, and the paucity of replicative studies using comparable methods, it was decided to use the same CT scanner and method as in the study of Bondareff *et al* (1981) to examine a new, larger, series of elderly demented patients and controls. This method was chosen as it had fewer drawbacks, than others. The use of a very large brain sample area increases the probability of the inclusion of unwanted areas such as sulci and it might be argued that the finding of lower attenuation density in demented patients by Naeser *et al* (1982) reflected the inclusion of atrophic sulci in the whole and quarter slices which they sampled. Conversely the use of very small brain sample areas might be expected sometimes to result in unrepresentative areas of a particular region being sampled. Furthermore, a small shift in the cursor could result in a quite different reading. The use of high convexity and centrum semi-ovale slices, as in the study by George *et al* (1981), introduces the possibility of obtaining elevated density readings in patients with dementia, where with ventricular enlargement these slices selected would tend to be pushed higher. It is recognised that as one approaches the apex, brain density readings increase (De Chiro *et al*, 1978). Similarly brain density readings taken at the convexity of the brain as in the study by Gado *et al* (1983), might be expected to be raised through the inclusion of partially volumed bone although this would affect both controls and patients with dementia. The method chosen for the present study

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utilises a brain sample size of intermediate area and avoids high slices and convexity readings.

Method

Subjects

Subjects consisted of a group of 48 patients who were diagnosed as having senile dementia of the Alzheimer type (SDAT) and were hospital inpatients, outpatients, day-patients or attending a day centre. Controls were a group of 40 normal elderly volunteers who were living independently in the community and showed no evidence of dementia or psychiatric disorder. Informed consent was obtained from all participants or, where not possible, the closest relative. The diagnosis of dementia was made on the basis of progressive global deterioration of higher cerebral function, of at least 6 months duration excluding those patients who had histories of stroke, head injury, alcoholism or major psychiatric illness. Other exclusion criteria were the presence of focal neurological signs, a measured blood pressure greater than 160 mmHg systolic or 100 mmHg diastolic and evidence of an underlying cause of dementia such as vitamin B12 or folate deficiency, endocrine disorder, metabolic disturbance or syphilis. All subjects were interviewed using a semi-structured interview [the Geriatric Mental State Schedule (GMSS) (Copeland *et al*, 1976)], underwent a full neurological examination, were given a test of memory and orientation, The Mental Test Score (MTS) (Hodkinson, 1973) and performed the Digit Copying Test (DCT) (Kendrick, 1965).

Computed tomography

Subjects were examined using the Maudsley Hospital EMI CT 1010 head scanner. Eight slices were made parallel to the orbitomeatal line. An EMI Independent viewing centre (IVC 464) was used to read the scans. Those scans with no more than minimal movement artefact were selected, displayed on a television screen and, by means of a tracker ball, an approximately circular area of 37 pixels was superimposed on anatomical regions of interest in appropriate slices. The mean attenuation density in Hounsfield units (HUs) was then calculated using a computer programme. Further details of the method are described by Bondareff *et al* (1981). In addition the ventricular–brain ratio (VBR), that is the ratio of maximum ventricular area to internal skull area was determined using a planimeter. The correlation between the VBR of the same scans by independent raters is high ($r = 0.98$, $P < 0.001$; Jacoby *et al*, 1980). A linear measure of the maximum width of the frontal horns of the lateral ventricle to the maximum internal skull diameter (bifrontal/intracranial ratio) was also determined for each subject.

TABLE I

Correlation between cognitive measures and those of lateral ventricular size

	VBR	*Bifrontal–intracranial ratio*
MTS	−0.70	−0.61
DCT	−0.67	−0.55

All significant at $P < 0.001$

TABLE II

Mean attenuation density in HU's and s.d. in different brain regions and analysis of variance

Region	*Hemisphere*	*Patients with senile dementia (n = 48)*	*Normal elderly controls (n = 40)*	*F (d.f. = 1)*	*P*[2]
Cerebellum	L	42.24 ± 3.91	43.37 ± 4.54	2.47	NS
Cerebellum	R	42.77 ± 4.11	43.36 ± 3.88	0.73	NS
Pons		35.45 ± 4.41	37.29 ± 4.87	2.87	NS
Medial temporal	L	38.08 ± 5.11	37.43 ± 9.15	0.82	NS
Medial temporal	R	37.54 ± 5.23	39.59 ± 4.89	1.62	NS
Anterior frontal	L	39.90 ± 4.09	40.02 ± 3.71	0.18	NS
Anterior frontal	R	39.63 ± 4.24	39.24 ± 3.37	0.08	NS
Caudate	L	38.20 ± 3.86	38.89 ± 2.60	2.35	NS
Caudate	R	37.57 ± 4.73	38.47 ± 2.72	0.84	NS
Thalamus	L	38.28 ± 2.78	39.03 ± 1.80	1.16	NS
Thalamus	R	37.54 ± 2.96	37.83 ± 1.91	0.12	NS
Parietal	L	39.15 ± 2.85	38.84 ± 3.43	0.61	NS
Parietal	R	38.12 ± 2.70	38.73 ± 3.91	0.26	NS
Occipital	L	41.95 ± 3.44	42.55 ± 3.58	0.48	NS
Occipital	R	41.53 ± 3.54	42.28 ± 3.50	0.63	NS

1. NS indicates not significant analysis of variance.
2. HU indicates Hounsfield Units.

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Results

The mean age of the demented subjects (77.9 ± 8.4) did not differ significantly from that of the control group (75.0 ± 8.3). The preponderance of females was similar in both groups (38 of 48 *vs* 31 of 40).

Demented subjects performed significantly worse than normals both on the Mental Test Score (10.3 ± 5.8 *vs* 31.8 ± 3.0, $P<0.001$) and the Digit Copying Test (28.8 ± 22.7 *vs* 82.2 ± 34.3, $P<0.01$).

Ventricular size was larger in the demented patients than in the control subjects both as assessed by the VBR (18.7 ± 4.2 *vs* 9.5 ± 4.1, $P<0.001$) and by the linear bifrontal/intracranial ratio (38.7 ± 4.1 *vs* 31.9 ± 4.3, $P<0.001$).

Cognitive measures were found to correlate negatively with those of ventricular size when the total sample of normal controls and demented patients was examined but not for the separate groups (Table I).

Although attenuation density was generally lower in SDAT subjects this was not significant in any region when demented and normal subjects were compared (Table II).

Correlations between regional density measurements and cognitive tests were in general low and not statistically significant with the exception of those between the MTS and pontine density ($r=0.31$, $P>0.004$), MTS and left thalamic density ($r=+0.20$, $P>0.03$) and between the DCT and density in the right occipital region ($r=+0.23$, $P>0.04$).

Discussion

The finding that patients with SDAT have significantly larger lateral ventricles than a group of normal control subjects of a comparable age is consistent with reports by other workers (de Leon, *et al*, 1960; Jacoby & Levy, 1980; Brinkman *et al*, 1981; Gado *et al*, 1982). Cognitive measures were found to correlate with those of ventricular size only when the demented and normal control groups were amalgamated as was found by Jacoby & Levy (1980). Scattergrams are provided of scores on the cognitive measures against VBR for normal controls and demented patients combined (Figs 1 and 2). That there were few large or statistically significant correlations between regional attenuation densities and cognitive measures is in keeping with a report by Naguib & Levy (1982) who used the same EMI scanner but a different group of patients. Higher correlations between CT density and cognitive measures have been reported by other workers (de Leon *et al*, 1980) but this may reflect the use of a more advanced scanner or to differences in sampling technique of regions of interest. Unfortunately de Leon & George (1983) do not state what size area of each region of interest was sampled in their study.

The present findings do not suggest that patients with SDAT differ significantly from normal elderly with respect to CT mean attenuation density in any of the regions examined. Our findings do not, therefore, replicate those previously reported by Bondareff *et al* (1981) working with our group. He found significantly lower attenuation density bilaterally in the anterior frontal, medial temporal and caudate regions of a group of patients with senile dementia when they were compared with a group of normal elderly controls. We used the same EMI CT 1010 scanner and similar methodology to that of Bondareff *et al* (1981). It is not likely that the sampling of regions of interest differed greatly in that

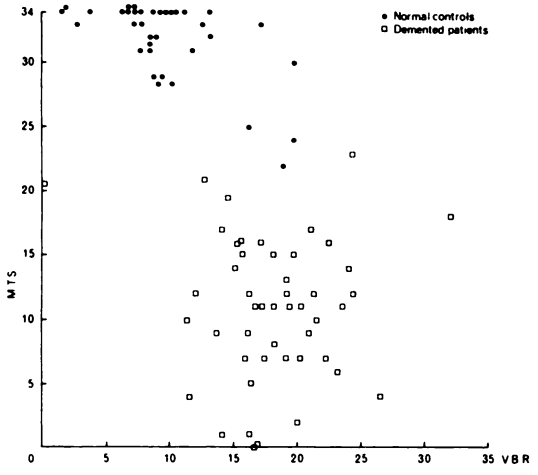


FIG. 1. Scattergram of Mental Test Score (MTS) against ventricular-brain ratio (VBR) for normal controls and demented patients ($r=-0.70$, $P<0.001$).

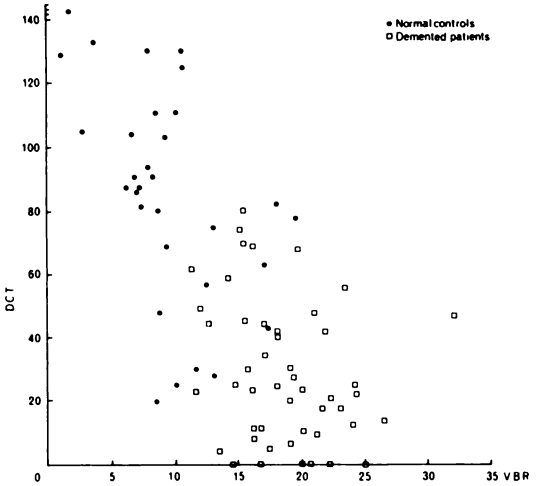


FIG. 2. Scattergram of scores on the Digit Copying Test (DCT) against ventricular-brain ratio (VBR) for normal controls and demented patients ($r=-0.67$, $P<0.001$).

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the density measurements by the present investigators on the same scans correlated highly ($r=0.93$, $P<0.001$). Scanner drift does not appear to be a likely source of variation in that densities were not found to correlate with date of scan over a 6 month period and a plot of density readings from a phantom over time did not suggest any systematic drift. A possible, although speculative, explanation for the difference in findings of the present study and that of Bondareff *et al* (1981) might be that the samples of demented patients studied were not comparable. Whilst both studies selected patients whose symptoms conformed to the ICD 9 criteria for senile dementia they differed in that those patients in the present study whose blood pressure exceeded 100 mmHg diastolic or 160 mmHg systolic were excluded. The 25 scans used by Bondareff *et al* (1981) were selected from the series of 40 patients reported by Jacoby & Levy (1980). Although in this series patients with hypertensive disease were not included those with high blood pressure alone were deliberately not excluded. Jacoby & Levy (1980) reported 10 patients with silent infarcts and these were significantly more likely to have had a diastolic blood pressure greater than 100 mmHg. It is possible that were many of these patients with silent infarcts to have been included in the sample studied by Bondareff *et al* (1981) this may have predisposed the finding that the demented group had lower attenuation density in some regions, alternatively it may be that patients with raised blood pressure have different CT attenuation densities from those who are normotensive.

In conclusion, it would appear that attenuation density does not significantly differentiate senile dementia subjects from age-matched controls although this method appears to show differences within the dementia group in that low attenuation in the parietal regions is associated with a more rapid demise (Naguib & Levy, 1982; Colgan, 1985). Further studies should therefore concentrate on the use of this method to isolate subgroups with different clinical courses rather than attempting to employ it as a diagnostic procedure.

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References

BONDAREFF, W., BALDY, R. & LEVY, R. (1981) Quantitative computed tomography in senile dementia. *Archives of General Psychiatry*, **38**, 1365–1368.

BRINKMAN, S. D., SARWAR, M., LEVIN, H. S. & MORRIS, H. H. III. (1981) Quantitative indexes of computed tomography in dementia and normal aging. *Radiology*, **138**, 89–92.

COLGAN, J. (1985) Regional density and survival in senile dementia—an interim report on a prospective computed tomography study. *British Journal of Psychiatry*, **147**, 63–66.

COPELAND, J. R., KELLEHER, M. J., KELLETT, J. M. *et al* (1976) A semi-structured clinical interview for the assessment of diagnosis and mental state in the elderly: the geriatric mental state schedule 1. Development and reliability. *Psychological Medicine*, **6**, 439–449.

DI CHIRO, C., BROOKS, R. A., DUBAL, L. & CHEW, E. (1978) The apical artefact: elevated attenuation values towards the apex of the skull. *Journal of Computer Assisted Tomography*, **2**, 65–70.

GADO, M., HUGHES, C. P., DANZIGER, W. *et al* (1982) Volumetric measurements in cerebrospinal fluid spaces in demented subjects and controls. *Radiology*, **144**, 535–538.

——, DANZIGER, W., CHI, D. *et al* (1983) Brain parenchymal density measurements by CT in demented subjects and normal controls. *Radiology*, **147**, 703–710.

GEORGE, A. E., DE LEON, M. J., FERRIS, S. H. & KRICHEFF, I. I. (1981) Parenchymal CT correlates of senile dementia (Alzheimer disease): Loss of gray white matter discriminability. *American Journal of Neuroradiology*, **2**, 205–213.

HODKINSON, H. M. (1973) Mental impairment in the elderly. *Journal of the Royal College of Physicians*, **7**, 305–317.

JACOBY, R. & LEVY, R. (1980) Computed tomography in the elderly: 2 Senile dementia: diagnosis and functional impairment. *British Journal of Psychiatry*, **136**, 256–269.

——, —— & DAWSON, J. (1980) Computed tomography in the elderly: 1 The normal population. *British Journal of Psychiatry*, **136**, 249–255.

KENDRICK, D. C. (1965) Speed and learning in the diagnosis of diffuse brain change in elderly subjects; A Bayesian statistical approach. *British Journal of Clinical and Social Psychology*, **4**, 141–148.

DE LEON, M. J. & GEORGE, A. E. (1983) Computed tomography in aging and dementia of the Alzheimer type. In *Advances in Neurology* Vol. 38 (eds R. Mayeux and W. Rosen). New York: Raven Press.

——, FERRIS, S. H., GEORGE, A. E. *et al* (1980) Computed tomography evaluations of brain-behaviour relationships in senile dementia of the Alzheimer's type. *Neurobiology of Aging*, **1**, 69–79.

NAESER, M. A., ALBERT, M. S. & KLEEFIELD, J. (1982) New methods in the CT scan diagnosing of Alzheimer's disease: examination of white and gray matter mean CT density numbers. In *Alzheimer's disease: a report of progress. Aging*, Vol. 19 (eds S. Corkin *et al*). New York: Raven Press.

NAGUIB, M. & LEVY, R. (1982) Prediction of outcome in senile dementia—a computed tomographic study. *British Journal of Psychiatry*, **140**, 263–267.

WILSON, R., FOX, J., HUCKMAN, M. *et al* (1982) Computed tomography in dementia. *Neurology*, **32**, 1054–1057.

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