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Use of computerized tomography in senile dementia[1]

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SYNOPSIS Computerized tomography was used to evaluate 35 patients with senile dementia and proved to be a simple and practical screening procedure. Those patients with moderate or severe cerebral atrophy had a poorer short-term prognosis than those with questionable or mild atrophy. Two patients with potentially treatable illnesses (hypothyroidism and pernicious anaemia) and only questionable atrophy had reversal of the dementia with treatment. A single patient with moderate atrophy had a potentially treatable illness (hypothyroidism) which only partially resolved. Those patients with dementia but relatively little atrophy by computerized tomography may represent a unique group with a better prognosis who require particularly careful evaluation for potentially treatable illnesses.

Computerized tomography (CT scanning) is a new method of visualizing cerebral structures including the ventricular system and cortical sulci (Ambrose and Hounsfield, 1973; Baker *et al.*, 1974; New *et al.*, 1974). Its value in the diagnosis of brain tumours, haemorrhages, and infarctions is becoming rapidly apparent. CT scanning has unusual promise in the evaluation of patients with dementia since, besides excluding occult mass lesions, the amount of ventricular enlargement and sulcus atrophy can actually be seen. Unlike the pneumoencephalogram, it is a non-invasive procedure without complications and can be used as a screening procedure for many illnesses.

Dementia is distressingly common in the geriatric population. The physician's responsibility includes exclusion of potentially treatable illnesses such as mass lesions, hypothyroidism, pernicious anaemia, and hydrocephalus. Multiple radiological procedures are frequently impractical in this group of patients. Tests which may help in determining the prognosis are as yet unavailable. The goal of this study was to evaluate the usefulness of computerized tomography in a carefully studied group of patients with senile dementia.

METHODS

Senile dementia was defined as the presence in an

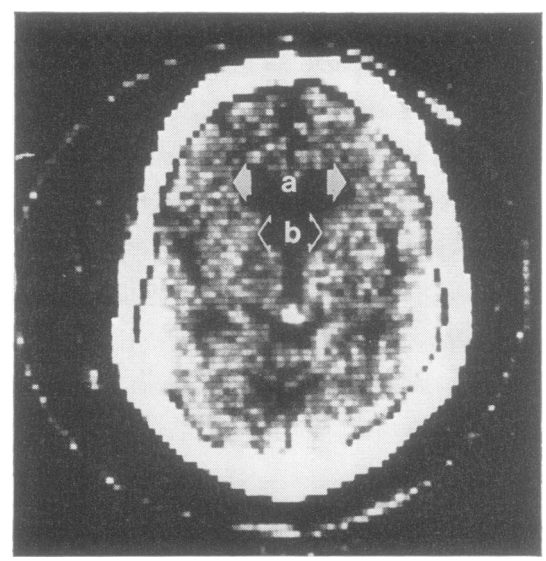

FIG. 1 a. *Line drawn between the most lateral portion of each of the frontal horns.* b. *The width of the lateral ventricles in the region of the caudate nuclei.*

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elderly patient of impaired orientation, judgment, and intellectual function for at least one month. Patients with a clear history of a stroke causing the intellectual decline and those with major focal findings such as hemiplegia on the neurological examination were excluded. Sixty years was the initial lower age limit. Shortly after starting the study this was changed to 65 years. Forty consecutive patients with senile dementia seen by the Neurology Department, Presbyterian-St Luke's Hospital, were included. Thirty-seven of the patients were seen by at least one of the authors, the remaining three by other members of the Neurology Department.

All of the patients had a complete investigation including a complete blood count, blood chemical analysis, estimation of T_4, B_{12}, and folic acid level. Each patient also had a skull radiograph, EEG, brain scan, and lumbar puncture. Computerized tomography was carried out on all patients. In four patients the scan was technically inadequate. A single patient was found to have a brain tumour and is not included. The remaining 35 patients are the subject of this study.

The procedures used to diagnose cerebral atrophy by computerized tomography and evidence of their validity are described elsewhere (Huckman *et al.*, 1975). Briefly, the radiologist (MSH) blindly evaluated each scan and measured the following dimensions:

a. a line drawn between the most lateral portion of each of the frontal horns (Fig. 1),

b. the width of the lateral ventricles in the region of the caudate nuclei, that being the width of the two

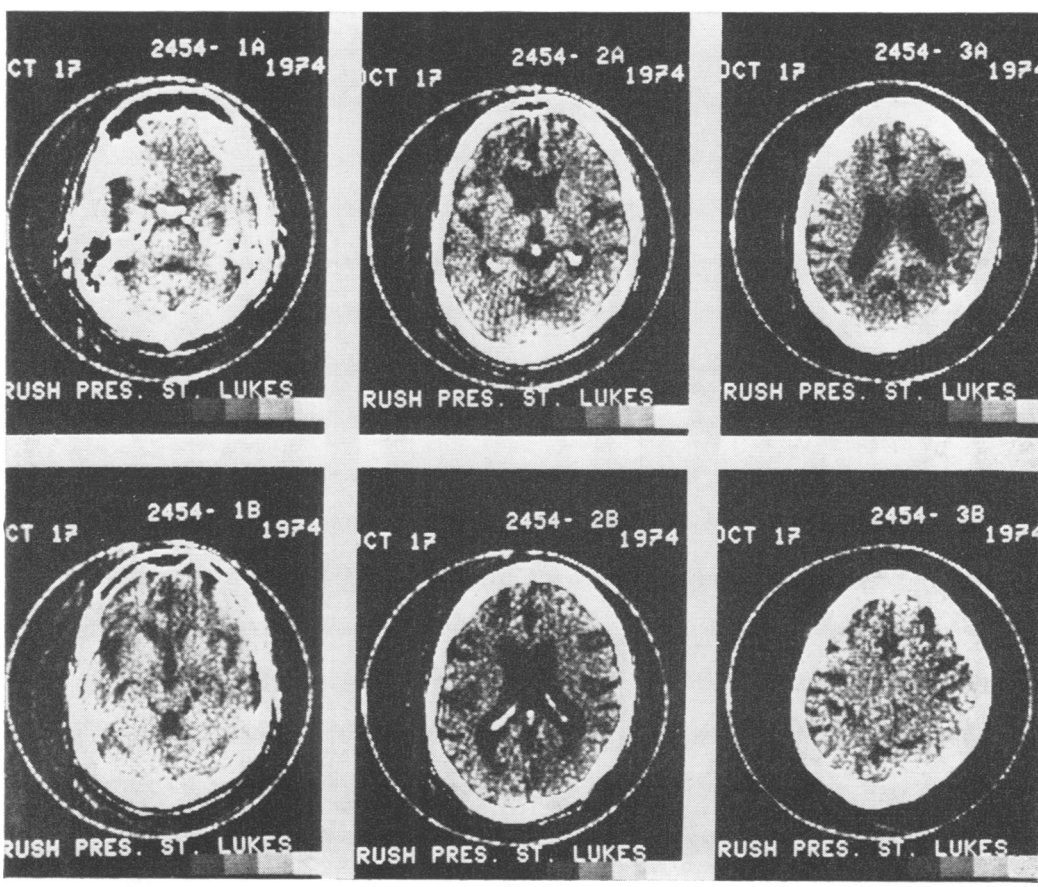

FIG. 2 *Severe cerebral atrophy. Note very large ventricles. Enlarged cortical sulci best seen on 3A and 3B cuts.*

lateral ventricles just anterior to the third ventricle (Fig. 1),

c. the total width of the four largest cortical sulci seen in the highest two tomographic cuts (Fig. 2).

The a and b measurements were added together and the sum was taken as the measurement of ventricular size. These measurements were expressed in millimetres as measured on the photographs. Multiplying these values by a factor of 3.63 would give the actual dimension being measured. For the purposes of this study, results are expressed as millimetres measured on the Polaroid photographs.

In each case, the sum of the a and b measurements as determined in millimetres on the photograph was taken as the ventricular size. The sum of the four largest sulci as measured in millimetres in the two uppermost tomographic cuts was the numerical value of the degree of sulcus enlargement. Though the line printout gave similar information, the Polaroid photograph was used for these measurements to make it simpler and more practical as a

TABLE

SEE TEXT FOR EXPLANATION

CT scan and patient number	*Sex*	*Age (yr)*	*Length of dementia history (yr)*	*Length of follow-up (months)*	*Disposition*	*Outcome*
Normal						
1	F	72	7	5	NH	No change
Questionable atrophy						
2	M	76	6 m	10	H	Cured (hypothyroid)
3	F	82	6 m	5	NH	No change
4	F	76	12	6	NH	Cured (pernicious anaemia)
5	F	84	1			Lost to follow-up
6	F	75	2 m	10	NH	No change
7	F	78	1	8	H	Better
Mild atrophy						
8	M	81	2 m			Died in hospital
9	M	73	1 m	8	H	No change
10	M	70	1	6	NH	Slightly worse
11	F	76	2	7	NH	No change
Moderate atrophy						
12	M	76	6 m	10 d	NH	Died 10 d after discharge
13	M	81	1 m	8	H	No change
14	M	69	5	8	NH	No change
15	M	80	1 m	7	NH	Gradually worse
16	M	74	4			Lost to follow-up
17	F	78	1	7	NH	Gradually worse
18	F	81	1	5	NH	Gradually worse
19	F	80	3 m			Lost to follow-up
20	M	72	2	5	NH	Died in NH 5 m after discharge
21	M	73	6 m	12	NH	Somewhat better (hypothyroid)
22	M	75	10	1	H	Died at H 1 m after discharge
23	M	65	3	9	NH	Possibly better
Severe atrophy						
24	M	74	3	9	H	No change
25	F	75	2 m	8	Unknown	Died (unknown if H or NH)
26	M	70	2 m	8	H	Died after 8 m at H
27	M	93	6 m	7	NH	Better
28	M	70	1 m	2	NH	Died after 2 m in NH
29	M	71	3 m	10	NH	No change
30	M	73	2	7	H	Possibly better
31	M	66	5	6	H	No change
32	M	77	3	6	NH	No change
Very large ventricles with normal sulci						
33	F	73	1	7	NH	Better
34	F	69	3	7	NH	No change
35	M	63	2			Died in hospital (probable low pressure hydrocephalus)

H: home. NH: nursing home.

screening tool. On the basis of these measurements, each of the cases was put into the following six categories.

I. Normal by CT examination. The ventricles measured 15 mm or less; the measurement of the cortical sulci was 5 mm or less.

II. CT examination showed questionable atrophy. The ventricles were between 16 mm and 20 mm and the sulci were 5 mm or less; or the ventricles were 15 mm or less but the sulci were between 6 mm and 9 mm.

III. CT examination showed mild atrophy. The ventricles measured between 16 mm and 20 mm and the sulci between 6 mm and 9 mm.

IV. CT examination showed moderate atrophy. The ventricles were greater than 20 mm and the sulci measured between 6 mm and 9 mm; or the ventricles measured between 16 mm and 20 mm and the sulci were greater than 9 mm.

V. CT examination showed severe atrophy. The sulci were greater than 9 mm and the ventricles were greater than 20 mm (Fig. 2).

VI. CT examination showed enlarged ventricles without enlarged cortical sulci. In this group the ventricular measure was greater than 20 mm but there were no large cortical sulci.

RESULTS

The results are presented in the Table. The patients will be divided into two groups for evaluation. The patients with no atrophy, questionable atrophy, and mild atrophy will be considered together ('normal–mild' group) as will those patients with moderate atrophy, severe atrophy, and very large ventricles ('moderate–severe' group).

The normal–mild group consisted of 11 patients, seven females, and four males. The average age was 77 years and the average length of history of dementia to the time of hospitalization was 28 months. Eight of these 11 patients had histories of one year or less. Two of these patients (patients 2 and 4) were found to have treatable illnesses causing the dementia (hypothyroidism and pernicious anaemia). In both these patients, the dementia resolved with appropriate treatment. Follow-up was available in 10 of the 11 patients with an average follow-up period of six months. One patient died in the hospital. Six of the remaining nine patients are in nursing homes and three are living with family. Most of the patients are relatively unchanged during the follow-up period.

The moderate–severe group consisted of 24 patients—six females and 18 males. The average age was 74 years and average length of dementia history was 24 months. Thirteen of the 24 patients had dementia for one year or less. A single patient (patient 21) was found to have a potentially treatable illness (hypothyroidism). He improved with therapy but still has a moderate degree of dementia. Interestingly, this patient also has severe Parkinson's disease. Follow-up is available in 22 of the 24 patients with an average follow-up period of six months. Seven patients have died, one in the hospital, three in nursing homes, and two at home, and one where the disposition is unknown. Of the remaining 15 patients, 11 are in nursing homes and four at home. Most are felt to be unchanged though a few are better and a few are worse.

DISCUSSION

Computerized tomography proved to be a simple screening test in this group of patients with senile dementia. Of the original series of 40, only four scans were technically inadequate because the patient moved. Oversedation can be risky in elderly patients and there probably always will be a few patients where satisfactory scanning is impossible. The single patient (not included in the Table) with a brain tumour was easily identified on the CT scan, though other screening procedures (brain scan and EEG) provided similar information.

Enlarged ventricles and enlarged sulci were easily identified. It should be pointed out that an occasional 'normal' elderly patient may demonstrate moderate or severe atrophy by computerized tomography though, in our experience, 85% of this group will have normal scans or only questionable atrophy (Huckman *et al.*, 1975). Whether CT scanning is adequate to rule out the low pressure hydrocephalus syndrome remains to be proven. Five patients had radio iodinated serum albumin (RISA) cisternography because they fitted the syndrome clinically (Adams *et al.*, 1965; Messert and Wannamaker, 1974). In four of these (three with severe and one with mild atrophy on computerized tomography) the RISA cisternography was within normal limits.

One of this group with severe atrophy on the CT scan and a normal RISA study had a pneumoencephalogram done. This confirmed the diagnosis of severe atrophy by the presence of greatly enlarged ventricles and cortical sulci. Only one patient (patient 35) was felt ultimately to have low pressure hydrocephalus. Interestingly, he was one of the three patients in group VI with marked ventricular enlargement without enlarged sulci. His pneumoencephalogram also showed enlarged ventricles without enlarged sulci and his RISA scan showed increased ventricular uptake with slow flow over the convexities. The other two patients in group VI were the only ones in our series with evidence on the CT scan of an old cerebral infarct. These two patients (patients 33 and 34) may belong in that relatively rare group of dementia patients without historical or physical evidence of old cerebrovascular accidents whose dementia is due to cerebrovascular disease. This group has been appropriately named 'multi-infarct dementia' (Hachinski *et al.*, 1974). The suggestion is that dementia patients with CT scan evidence of marked ventricular enlargement without either enlarged sulci or evidence of old cerebral infarcts, deserve further evaluation for the low pressure hydrocephalus syndrome. However, it is too early to state definitely that patients with dementia due to hydrocephalus may not have other patterns on computerized tomography (or other radiological procedures) (Shenkin *et al.*, 1973).

Three patients in this series were found to have potentially treatable metabolic illnesses. One of the patients with hypothyroidism and the single patient with pernicious anaemia had resolution of the dementia with appropriate therapy. Both of these patients were in the normal–mild group. A second patient with hypothyroidism had moderate atrophy. He also had severe Parkinson's disease and his dementia only partially resolved with treatment. The suggestion is that, though patients with moderate or severe atrophy may have treatable illnesses, the physician must be most suspicious of this possibility in patients with relatively normal scans or mild atrophy. This in no way lessens the need to do appropriate metabolic screening tests in all demented patients. It would seem appropriate, however, to follow carefully all demented patients in the normal–mild group for any potentially treatable illness, even if appropriate screening tests were initially normal.

Finally, the difference in short-term mortality between the normal–mild group and the moderate–severe group is quite striking. In patients with follow-up, one of 10 in the normal–mild group died as opposed to seven of 22 in the moderate–severe group. Major differences in the two groups are not readily apparent. The severity of the dementia ranged from mild to severe in both groups, and approximately similar proportions went home and to nursing homes. The average age, length of dementia history, and length of follow-up were not very different. There are proportionately far more females in the normal–mild group and more males in the moderate–severe group. Since seven of the eight deaths were in males, this may have some significance. However, other large studies of senile dementia have shown no difference in short or long-term mortality between males and females (Kay, 1962). The total mortality of 25% (eight of 32 with follow-up) for the average six month follow-up is very similar to the 40–50% mortality per year reported in patients with senile dementia (Kay, 1962), suggesting that our patient population is similar to those of other series.

Past studies have demonstrated a high mortality in patients with dementia and cerebral atrophy demonstrated on pneumoencephalography (Sjaastad and Lönnum, 1966; Mann, 1973). Correlation of prognosis with the degree of atrophy was not done. Our study suggests that patients with dementia and little or no atrophy may represent a separate group with a greater potential for finding treatable illness and a better prognosis. The applicability of computerized tomography for large groups of patients will, it is hoped, better define this group in the future.

REFERENCES

Adams, R. D., Risher, C. M., Hakim, S., Ojemann, R. G. and Sweet, W. H. (1965). Symptomatic occult hydrocephalus with 'normal' cerebrospinal fluid pressure. *New England Journal of Medicine*, **273**, 117–126.

Ambrose, J., and Hounsfield, G. (1973). Computerized transverse axial tomography. *British Journal of Radiology*, **46**, 148–149.

Baker, H. L., Campbell, J. K., Houser, O. W., Reese, O. F., Sheedy, P. F., and Holmal, C. B. (1974). Computer

assisted tomography of the head. *Mayo Clinic Proceedings*, **49**, 17–27.

Hachinski, V. C., Lassen, N. A., and Marshall, J. (1974). Multi-infarct dementia. *Lancet*, **2**, 207–209.

Huckman, M. S., Fox, J. H., and Topel, J. L. (1975). Criteria for the diagnosis of brain atrophy by computerized tomography. *Radiology*. (In press.)

Kay, D. W. K. (1962). Outcome and cause of death in mental disorders of old age: a long term follow-up of functional and organic psychoses. *Acta Psychiatrica Scandinavica*, **38**, 249–276.

Mann, A. H. (1973). Cortical atrophy and air encephalography: a clinical and radiological study. *Psychological Medicine*, **3**, 374–378.

Messert, B., and Wannamaker, B. B. (1974). Reappraisal of the adult occult hydrocephalus syndrome. *Neurology (Minneap.)*, **24**, 224–231.

New, P. F. J., Scott, W. R., Schnur, J. A., Davis, K. R., and Taveras, J. M. (1974). Computerized axial tomography with the EMI scanner. *Radiology*, **110**, 109–123.

Shenkin, H. A., Greenberg, J., Bouzarth, W. F., Gutterman, P., and Morales, J. O. (1973). Ventricular shunting for relief of senile symptoms. *Journal of American Medical Association*, **225**, 1486–1489.

Sjaastad, O., and Lönnum, A. (1966). Long-term prognosis of patients with central cerebral ventricular enlargement. *Acta Neurologica Scandinavica*, **42**, 317–353.