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Brain Atrophy in Dementia Judged by CT Scan Ranking

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In order to further investigate the relationships of brain atrophy, age, and dementia, computed tomographic (CT) scans on two groups of subjects aged 65–80 years were rank-ordered according to ventricular and sulcal size. Each group contained subjects with mild senile dementia of the Alzheimer type (SDAT) and matched controls. In both experiments there was a strong correlation between these rank orders, ventricular size, and the clinical dementia rating. There was also a weaker but significant correlation between rank ordering and sulcal size. This suggests that brain atrophy in excess of that normal for age alone occurs in early SDAT.

Since computed tomography (CT) was introduced in 1973 for clinical use considerable interest has focused on the question of whether or not there is progressive atrophy of the brain associated with senile dementia of the Alzheimer type (SDAT) apart from that associated with the aging process. In an earlier publication we reviewed these studies [1] and confirmed the clear association of brain atrophy and age as determined by linear measurements of ventricles and sulci. Using these techniques there are conflicting data on the association of atrophy and dementia [1–5].

Two previous groups [6, 7] used a method whereby scans were rank-ordered by an experienced neuroradiologist according to increasing ventricular and sulcal size. De Leon et al. [6] concluded that there were significant correlations between both ventricular and sulcal rankings and various measures of dementia, while Ford and Winter [7] found that this was true only for ventricular rankings.

In the Washington University Memory and Aging Project a carefully selected group of subjects with definite but mild SDAT and matched controls is being longitudinally studied with a variety of cognitive, anatomic, and physiologic measures. It was considered useful to reexamine CT scans in those subjects using the rank-ordering process.

Materials and Methods

Fifty-eight subjects (33 with mild SDAT, 25 controls) were initially studied on the EMI 7070 Scanner. The mean age for demented subjects was 72.3 ± 5.1 years and for controls 72.1 ± 4.1 years. All of the subjects were living in the community and were assigned a Clinical Dementia Rating (CDR) [8] of CDR 0 (no dementia) or CDR 1 (mild dementia). Another group of the same subjects was studied later on a Siemens Somatom II. This group of 47 subjects included 20 with mild SDAT and 27 controls (two controls were not included in the EMI 7070 study) with mean ages of 7.13 ± 4.4 years and 71.3 ± 4.7 years, respectively.

CT scans were obtained in a similar manner on both scanners. The images from an 8 mm nonoverlapping section oriented to the plane of the orbitomeatal line were processed on a 312 × 312 matrix by the EMI 7070 and a 256 × 256 matrix with the Somatom II. Images were filtered to reduce the noise level to 1–2 Hounsfield units (H) with the latter scanner. Positive images were produced on photographic film for review. To facilitate this review the scans were numbered so that the radiologist did not know the CDR and they were then rank-ordered separately according to ventricular or sulcal size using the subjective impression of the observer as the basis of ranking. Each of the 58 subjects in the first group was assigned a separate rank on a scale of 1–58. Rank 1 was assigned to the subject whose CT scan was judged by the observer as showing the smallest ventricles of the whole series, and rank 58 the largest. Two experienced neuroradiologists (M. G. and J. P.) performed this task for the first group; the second group was ranked by M. G. only.

The scans obtained on the EMI 7070 from the initial group of 58 subjects were also analyzed with linear measurements previously described [1]. The linear measurements of the span of the frontal horns, the septum caudate spans, the width of the body of the lateral ventricles, and the width of the third ventricle were added. From the sum of these measurements a ventricular score (VS) was derived as a percentage of the maximum width of the cranial cavity. No linear measurements for the cerebral sulci were obtained.

Results

EMI 7070 (58 Scans)

In the first phase of the study there was a better correlation between the two observers in making the rankings of ventricles (0.89, $p = 0.0001$) than for the rankings of sulcal size (0.68, $p = 0.0001$). The comparison between the rank-ordering of ventricles and sulci by the two observers and the CDR is shown in table 1. Except for the ranking of sulci by observer 1, these rankings are related to the presence or absence of mild dementia. As expected, the subjective ventricular rankings related strongly to the linear measures of ventricle size as represented by the ventricular score (for both observers, $r = 0.8$, $r^2 = 0.64$, $p = 0.0001$), and the VS correlated well with the presence or absence of dementia ($p < 0.01$).

TABLE 1: **Relations between CT Ventricular and Sulcal Rankings and Clinical Dementia Ratings**

Observer No.: Rank	Controls (n = 25)	Demented (n = 33)	F	p
1:				
Ventricle ..	20.04	36.67	17.87	0.0001
Sulcal	28.40	30.33	0.18	NS
2:				
Ventricle ..	21.04	35.91	13.43	0.0006
Sulcal	24.16	33.55	4.68	0.035

Note.—NS = not significant.

Somatom II (47 Scans)

As a replication study 47 scans from the same group of subjects but with the use of the Somatom II Siemens scanner were rank-ordered by observer 1 (M. G.) The correlation between the subjective ventricular rankings and the CDR was highly significant ($p = 0.0001$) and that between the sulcal rankings and the CDR less so ($p < 0.05$).

Discussion

The good interrater correlation suggests that this method of rank-ordering is sufficiently reliable for the evaluation of a large group of CT scans. In addition these findings confirm the original work of de Leon et al. [6] and Ford and Winter [7] indicating that the presence of dementia is accompanied by somewhat more brain atrophy than could be accounted for by age alone. The subjects were living in the community and exhibited either no dementia or mild dementia, implying that increased brain atrophy may appear very early in the course of SDAT. While the subjects of Ford and Winter [7] were hospitalized and were possibly more severely involved, those studied by de Leon et al. [6] appear similar to our group.

Our results show that rank-ordering of the ventricles was more related to the presence or absence of dementia than was rank-ordering of the sulci. In comparing two scans the observer is more likely to correctly compare the sizes of the ventricular systems than the sulci, since with the latter the observer has to deal with two distinct elements: the number of visible sulci and the size of each individual sulcus. The poorer correlation between ranking the sulci and the presence or absence of dementia may therefore be due to

difficulty in judging the total sulcal size as compared with the greater ease of ventricular judgments.

Because of the superior qualities of the Somatom II scanner we are now using volumetric measures of brain atrophy, and a preliminary report [9] suggests that both ventricular and sulcal size correlate strongly with mild dementia (presumptive SDAT) when age is controlled.

Rank-ordering groups of scans is not a technique suitable to the evaluation of an individual patient, and our experience with linear measures has shown that these are not as sensitive to the presence of dementia as the volumetric ones [9]. It is hoped that serial studies in these subjects will reveal measurements that predict progressive SDAT in individuals. Such findings would be not only of diagnostic value but useful in the construction of future therapeutic trials.

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