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FRONTAL VENTRICULAR DIMENSIONS ON NORMAL COMPUTED TOMOGRAPHY

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ABSTRACT:

The computerized axial tomographic examinations of 200 normal patients and volunteers between the ages of ten to 81 years were evaluated. Determination of the ratio between the width of the brain and a dimension representing the distance between the outer borders of the lateral ventricles was made at two levels. This ratio, the cerebroventricular index, seems to be a reliable indicator of ventricular size. The standards vary with the age of the patient.

ALTHOUGH the computerized axial tomographic (CT) scan of the brain is accepted as a valuable procedure for the evaluation of cerebral ventricular size, the normal range of ventricular size as seen on the CT scan has not been established in the literature. The recognition of mild or moderate ventricular dilatation or reduction on the CT scan has been based on experience, and the lack of any quantitative data has led to some controversy. For the purpose of establishing quantitative criteria of ventricular size for comparative diagnoses, 200 normal CT scans and 65 abnornal CT scans were studied.

The frontal ventricular dimensions as measured by a Vanguard Motion Analyzer are correlated with age and provided in this paper.

MATERIAL AND METHOD

From the University of Iowa Hospital's computer memory bank containing the CT scan data of over 1,500 patients, the investigators screened and assembled the data for normal sized ventricles and various types of abnormalities. (The present report emphasizes the study of normal ventricles.) The normal CT scans were derived from 180 patients who were ultimately considered neurologically normal, and from 20 normal volunteers. These 200 normal individuals included 97 males and 103 females with an age range from ten to 81 years.

CT scans were performed in a standard fashion[1,2,3] with an approximate 15 degree tilt from the canthomeatal line. In all cases 2A and 2B images were utilized because they provided the best images of the frontal horn; 2B images frequently showed the maximum bicaudate diameter to best advantage. Initially, the measurements were derived in the traditional manner from the original Polaroid images utilizing a ruler. In order to minimize the potential measurement error, the investigators subsequently transposed all the tomographic Polaroid images on a roll of 35 millimeter film and then projected each film frame with proper magnification on the screen of a Vanguard Motion Analyzer. This is a precision reader whose accuracy is better than 0.1 percent in linear measurements. The dimensions of each subject measured on the analyzer screen were automatically digitized and transcribed on an IBM card through key punching. In each case, the following dimensions were measured:

A. The maximum bifrontal diameter: the transverse distance defined by a line connecting the two anterior corners of the frontal horn (Fig. 1).
B. The first transverse dimension of the brain (brain width): the distance measured along the line of the bifrontal diameter from the right to the left cortical surfaces (Fig. 1).

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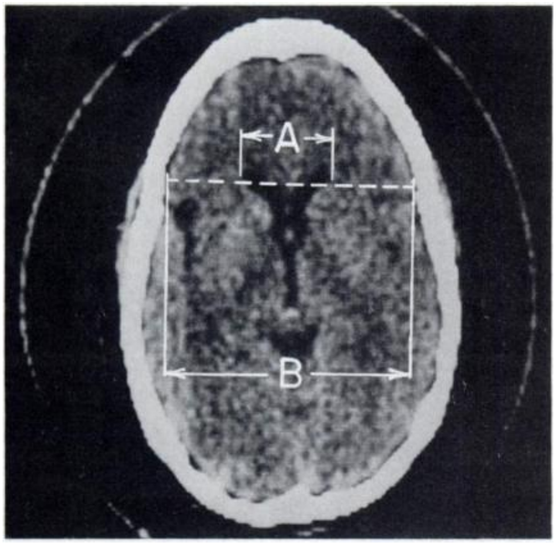

FIG. 1. Illustration of measurements A and B, respectively, the maximum bifrontal distance and the first transverse dimension of the brain.

C. The maximum bicaudate diameter—the transverse dimension through the body of the frontal horn measured along a line drawn from the midportion of the head of one caudate nucleus to the other (Fig. 2).

D. The second transverse dimension of the brain (brain width)—the distance measured along a line extending from the right to the left cortical surfaces through the line of the bicaudate diameter (Fig. 2).

The A and C measurements provide two characteristic dimensions of the frontal ventricular horn, whereas B and D measurements reflect brain size. All measurements were made in millimeters. However, the A and C measurements were divided by two characteristic dimensions of the brain B and D, respectively, so as to ensure the independence of the results of the present study from particular scale factors utilized in sizing up the CT scan images as well as from the units of measurement employed; furthermore, the influence of variations in the size of the frontal horns due to anthropometric differences in normal individuals is minimized.

The ratios obtained are dimensionless and may be called the first (A/B) and second (C/D) cerebroventricular index (CVI) of the frontal horns. The first ratio multiplied by 100 gives the percent of the maximum bifrontal diameter (A) to brain width (B); and the second ratio (C/D) multiplied by 100 expresses that of the bicaudate diameter (C) to brain width (D). The results of the present study are therefore presented in terms of the percentage of the maximum bifrontal diameter (A) to brain width (B), and the percentage of the bicaudate diameter (C) to brain width (D).

RESULTS

These percentages, $(A/B)\times 100$ and $(C/D)\times 100$, are plotted with respect to age in Figures 3 and 4, respectively. A line representing a least square fit to all the points is drawn through each graph. Table I provides the mean, standard deviation, maximum, and minimum values of these percentages for the 200 normals investigated. As an illustration of the use of Table I as a standard reference, the results of the analysis of a group of 65 abnormals with ventricular dilatation from various causes are presented in Table II and may be com-

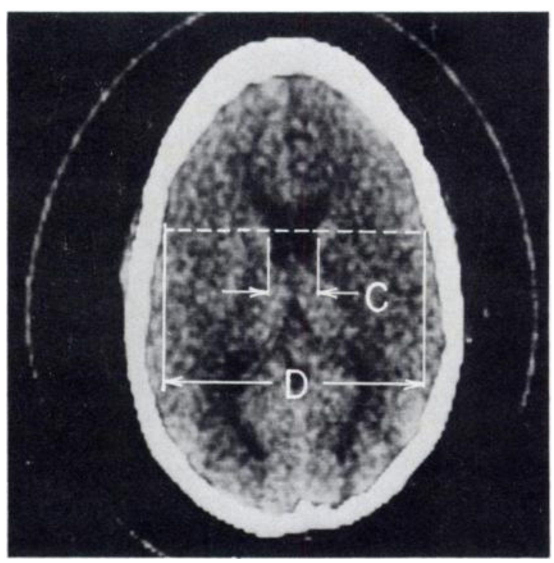

FIG. 2. Illustration of measurements C and D, respectively, the maximum bicaudate diameter and the second transverse dimension of the brain.

pared with those of normals. As a guide for comparative diagnosis, this study establishes that the maximum bifrontal diameter of the normal frontal ventricle varies from 19 percent to 39 percent of brain width B and its mean value for all ages is 31 percent with a standard deviation of four percent. The maximum bicaudate diameter of the normal frontal ventricle varies from eight to 23 percent of brain width D and its mean value for all ages is 15 percent with a standard deviation of three percent. Figures 3 and 4 also reveal the interesting tendency of the maximum bifrontal diameter of the normal frontal ventricle to increase with age, from approximately 28 percent of brain width B at the age of 15 years to 31 percent at the age of 70 years. The same is true for the bicaudate diameter of the normal frontal ventricle which measures approximately 13 percent of brain width D at the age of 15 years and 17 percent of brain width at the age of 70 years. The group of hydrocephalic patients which is presented only for purposes of comparison warrants the following observations: the mean bifrontal and bicaudate cerebroventricular indices in this group are increased approximately one and one-half to two times respectively, in comparison to the normal group.

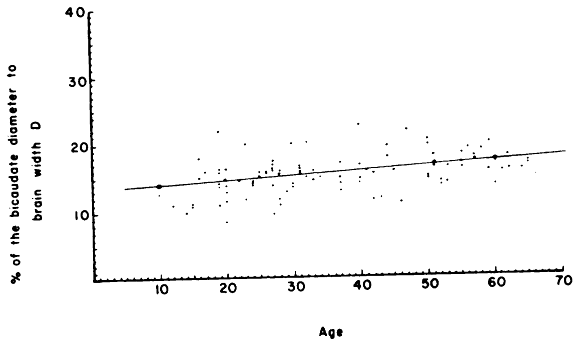

Fig. 4. Percentage of the maximum bicaudate diameter to brain width D *versus* age for 100 normal individuals.

DISCUSSION

Estimation of ventricular size can be accomplished in most instances by relying on the training and experience of the radiologist. Yet, the relative newness of CT scanning has not permitted the acquisition of extensive experience, and quantitative criteria are likely to prove helpful in some borderline cases: such criteria may also serve as objective standards against which one may test the diagnostic reliability which is presently based on reconditioning acquired in other techniques such as pneumoencephalography.

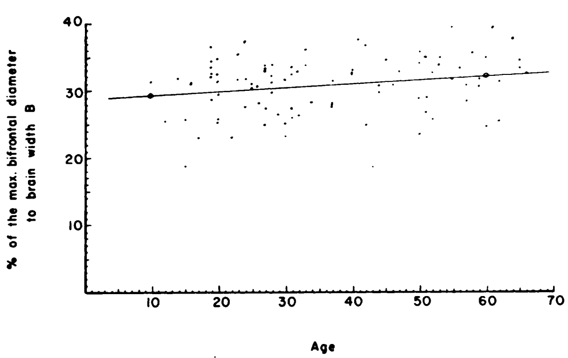

Fig. 3. Percentage of the maximum bifrontal diameter to brain width B *versus* age for 100 normal individuals.

The cerebroventricular index derived from the more dorsal portion of the frontal horns, *i.e.*, the bicaudate CVI, appears to be more sensitive than the bifrontal CVI in the detection of changes in ventricular size. Notwithstanding this expected observation, there is some overlap of the normal distribution curves derived from the normal and hydrocephalic groups of patients in this study. The mean and standard deviations derived from the two bell shaped curves characterizing the two patient groups are such that slightly less than five percent (4.55 percent) of each group's constituents are sufficiently remote from the mean to intersect with members of the other group; this measure may be held to reflect a minimum theoretical false positive or false negative rate respectively.

The principal objective of this brief report is to present the quantitative data pertaining to the size of the normal ventricular system as reported on CT scans. The

TABLE I

CEREBROVENTRICULAR INDICES (CVI) OF BIFRONTAL AND BICAUDATE DIAMETERS OF 200 NORMAL CT SCANS

	Mean (Percent)	Standard Deviation (Percent)	Minimum Value (Percent)	Maximum Value (Percent)
CVI of bifrontal diameter (A/B)×100	31.1	3.7	18.5	39.3
CVI of bicaudate diameter (C/D)×100	15.4	2.8	8.1	23.2

TABLE II

CEREBROVENTRICULAR INDICES (CVI) OF BIFRONTAL AND BICAUDATE DIAMETERS OF 65 ABNORMALS WITH VENTRICULAR DILATATION

	Mean (Percent)	Standard Deviation (Percent)	Minimum Value (Percent)	Maximum Value (Percent)
CVI of bifrontal diameter (A/B)×100	44.8	7.8	33.8	77.8
CVI of bicaudate diameter (C/D)×100	29.3	5.7	19.1	45.9

problems posed by alterations in size due to various pathologic processes will be considered in subsequent communications.

SUMMARY

Utilizing the Vanguard Motion Analyzer with computer analysis, 200 normal and 65 abnormal CT scans of the brain were studied. Normal ranges of bifrontal and bicaudate diameters of the frontal horn of the lateral ventricle, and ratios of these distances to the brain widths on the same levels were determined. The results are presented graphically.

It is suggested that a maximum bicaudate diameter greater than 22 percent or less than eight percent, or a maximum frontal diameter greater than 40 percent or less than 18 percent, of the widths of the brain on the corresponding levels are highly suspicious of abnormal ventricles.

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