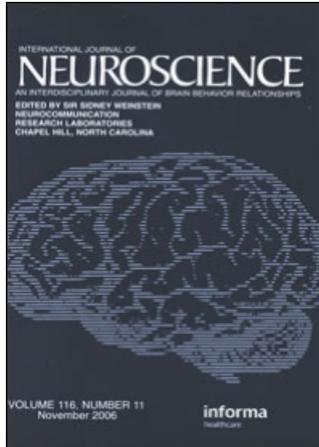


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Erin D. Bigler^a; Sydney Paver^b; C. Munro Cullum^b; Eric Turkheimer^b; Donn Hubler^c; Ron Yeo^d

^a Austin Neurological Clinic and the University of Texas at Austin,

^b University of Texas at Austin,

^c University of New Mexico,

^d Boston VA Hospital,

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VENTRICULAR ENLARGEMENT, CORTICAL ATROPHY AND NEUROPSYCHOLOGICAL PERFORMANCE FOLLOWING HEAD INJURY

ERIN D. BIGLER

Austin Neurological Clinic and the University of Texas at Austin

SYDNEY PAVER

University of Texas at Austin

C. MUNRO CULLUM

University of Texas at Austin

ERIC TURKHEIMER

University of Texas at Austin

DONN HUBLER

University of New Mexico

and

RON YEO

Boston VA Hospital

(Received December 28, 1983)

Volumetric measures of the ventricular system and the degree of cortical atrophy were obtained from CT scan data in 48 severe post-head-injury patients. Neuropsychological tests consisting of the WAIS, WMS and the HRNTB were obtained. Correlational analyses revealed significant negative relationships between ventricular size and intellectual and memory functioning, but no consistent relationship with measures of motor, sensory or language functioning. Similar, but generally less significant, findings were obtained with the atrophy index measure. Results are discussed in relation to differential effects of trauma on cerebral morphology and neuropsychological outcome.

A variety of structural brain changes may accompany cerebral trauma (Jennett & Teasdale, 1981; Levin, *et al.*, 1983). In the past, pneumoencephalography has demonstrated that as many as 50% of closed head injury (CGI) patients have subsequent ventricular enlargement (Hawkins, *et al.*, 1976). More recently, utilizing CAT scan data, Levin, *et al.* (1981) have demonstrated ventricular enlargement in 72% of their patients with CHI. The ventricular enlargement was negatively correlated with neuropsychological outcome. Measures of sulcal enlargement (cortical atrophy) were not found to correlate as well with neuropsychological deficit and outcome.

A limitation of past studies examining morphologic change and cognitive outcome in CHI, or other neurologic disorders, has been the use of singular, typically planimetric, measures which may not accurately estimate actual volume of the structure(s)

Address correspondence to: Erin D. Bigler, Ph.D. Austin Neurological Clinic, 711-F West 38th Street, Austin, Texas 78705. (512-458-6121).

under study (Bird, 1982). In the current study, we sought to correct this by taking various volumetric measures of ventricular and cortical structures.

METHODS

Total volumetric measures were obtained of the third and two lateral ventricles using the techniques outlined by Turkheimer, *et al.*, (1983) and Yeo, *et al.*, (1983). These methods permit an accurate estimate of total ventricular volume (excluding fourth ventricle), as well as left and right lateral ventricular volumes. A total brain surface area (BSA), ventricular surface area (VSA) and a total brain volume (TBV) were calculated. An atrophy index was developed by taking the BSA value and dividing it by the square root of the TBV value for each patient. The atrophy index could be further delineated into anterior and posterior measures as well as left and right. Similarly, the ventricular system was analyzed by quadrant analysis. Correlational statistical analyses were utilized.

48 patients were evaluated. All were at least 3 months post head-injury. Routine CT scanning was obtained on all patients. Neuropsychological studies consisted of a Wechsler Adult Intelligence Scale, Wechsler Memory Scale, and the Halstead-Reitan Neuropsychological Test Battery.

RESULTS

Neuropsychological results are presented in Table I. Correlational analyses were undertaken comparing the various volumetric measures with neuropsychological performance. The results indicate significant negative correlations with certain neuropsychologic measures, namely Performance Intellectual Quotient, Full Scale Intellectual Quotient, Memory Quotient and Category Test. No consistent correlations were found with any of the motor, sensory or language tests. Further analysis of ventricular volume measures indicated a very robust negative relationship between right lateral ventricle size, particularly surface areas, and neuropsychological deficit performance. Atrophy index measures yielded similar correlations, but typically not to the degree as those obtained with ventricular measures. One exception was that the atrophy index was strongly correlated with spatial and verbal deficits on the Reitan-Indiana aphasia screening test. Such relationships generally were not found with ventricular measures. Ventricular surface area generally was the most sensitive measure with respect to neuropsychologic impairment and all ventricular measures were significantly correlated with the atrophy index. Quadrant analysis revealed the strongest ventricle-neuropsychologic relationships to be associated with posterior (particularly right) regions. Measures of brain morphology alone (TBV, BSA) were uncorrelated with neuropsychological performance.

DISCUSSION

Volumetric ventricular measurements correlated negatively with the severity of neuropsychological outcome in terms of intellectual and memory functions, but not with motor, sensory or language functioning. Volumetric analysis of the ventricular system further indicated asymmetric effects with greater right lateral ventricular surface area

TABLE I

TEST	MEAN	S.D.
VIQ	89.7	19.1
PIQ	84.8	19.6
FSIQ	86.9	18.6
MQ	82.5	23.1
LM	6.2	3.7
DS	9.7	2.6
VM	6.8	4.4
AL	9.9	5.3
HRNTB		
SOGR	31.6	14.1
SOGL	29.4	16.4
FOR	37.2	12.7
FOL	33.8	10.7
*TPT-D	3.2	2.1
TPT-ND	3.7	1.6
TPT-B	3.5	1.5
^b SSPT	13.5	11.1
^b SSRT	6.9	3.4
*Aphasia Screening		
Verbal	2.1	1.4
Spatial	2.1	1.1
^b Sensory-Perceptual		
Total Right	2.4	2.1
Total Left	3.0	2.4
*Category Test	2.8	1.8

*scaled score based on the ratings established by Russell, Neuringer and Goldstein (*Assessment of brain damage: A neuropsychological key approach*. New York: Wiley, 1980).

^berror score.

and volume being strongly negatively correlated with global intellectual and memory deficits. The degree of cortical atrophy was also found to correlate negatively, although not to such a degree, with intellectual and memory functions, but also with language functioning. Again, no consistent relationship was found between motor and sensory functioning and atrophy index measures. Unlike the ventricular asymmetric volume findings, there was no consistent relationship between hemispheric atrophy and neuropsychological outcome. Quadrant analysis of ventricular size revealed the strongest correlations to be associated with posterior regions. Ventricular surface area measurements typically were found to be the most sensitive predictors of neuropsychological outcome.

The development of ventriculomegaly and cortical atrophy as a result of trauma are evidently interrelated, but also likely to a degree independent. Adams, *et al.*, (1977), have indicated that ventricular enlargement following head injuries is primarily associated with white matter tissue loss and that the enlargement is thus an *ex vacuo* process.

Similar effects are likely to occur at cortex resulting in atrophy, but additionally, contusing effects at the cortical level as a result of the skull/brain interface likely contribute to the presence of cortical atrophy. Such differences could account for the differential effects on ventricular size, degree of cortical atrophy and neuropsychological outcome. The relationship between certain morphologic measures of the brain in the post-traumatic state may have significant clinical implications for recovery of function.

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