Progression of Corpus Callosum Atrophy in Early Stage of Alzheimer's Disease:

MRI Based Study

Minwei Zhu, MD, Wenpeng Gao, PhD, Xudong Wang, MD, Chen Shi, BSc, Zhiguo Lin, PhD

Rationale and Objectives: Magnetic resonance imaging (MRI) studies reveal that atrophy of the corpus callosum (CC) is involved in early Alzheimer's disease (AD). The aim of this study was to investigate when and how callosal changes occur in the early course of AD.

Materials and Methods: The Open Access Series of Imaging Studies data sets were used in this study to investigate callosal change. High-resolution structural MRI was performed in 196 older patients. Subjects were characterized using the Clinical Dementia Rating (CDR); 98 healthy controls were not demented (CDR 0), and 98 patients had clinical diagnosis of AD in the very mild dementia stage (CDR 0.5; $n = 70$) and the mild dementia stage (CDR 1; $n = 28$). A semiautomatic segmentation method was used to extract the CC in the midsagittal plane. The total and regional areas of the CC were measured.

Results: The results indicated that callosal atrophy occurred in when subjects' CDRs were 0.5. The area of the genu and rostral body of the CC in the healthy controls (CDR 0) was significantly different from that of the subjects with very mild dementia (CDR 0.5) ($P < .05$). A significant difference could also be found in the area of the rostral body and midbody of the CC between subjects with very mild dementia (CDR 0.5) and those with mild dementia (CDR 1) ($P < .05$).

Conclusions: Callosal atrophy can be detected in subjects with CDRs of 0.5. The change in the CC in the early stage of AD indicates an anterior-to-posterior atrophic process as the degree of dementia assessed by the CDR (from 0 to 0.5 to 1) increases.

Key Words: Corpus callosum; magnetic resonance imaging; atrophy.

©AUR, 2012

Alzheimer's disease (AD) has been described as an irreversible, neurodegenerative brain disease and generally affects gray matter. Nevertheless, several researchers have revealed that AD is also associated with white matter pathology (1,2). The corpus callosum (CC), as the largest interconnecting white matter tract in the brain, may inevitably be affected by AD. Because the CC is responsible for most of the communication between the two cerebral hemispheres, it is important to understand how AD affects the CC.

Until now, many studies (3–12) have reported significant atrophy of the CC in the process of AD. Most of these studies included patients with AD in different stages of dementia, from mild to severe. In general, investigators have classified these heterogeneous patients as an AD group in advance. In comparison to normal controls, changes of the CC are analyzed using different methods, such as the region of interest (ROI) (4,6–14), voxel-based morphometry, and diffusion tensor imaging (3,10,12,13,15,16). With respect to callosal change assessed using magnetic resonance imaging (MRI), most researchers have focused on subjects with mild cognitive impairment (MCI), which is a transitional stage between normal cognitive function and AD. Controversial results have been reported in ROI studies of the CC in subjects with MCI. Wang and Su (16) found no callosal change between patients with MCI and healthy controls. Wang et al (12) detected atrophy in the posterior subregions. Thomann et al (10) reported reductions in anterior subregions of the CC in a group of patients with MCI. A survey of these works was performed by Di Paola et al (17), revealing that changes in the anterior and posterior portions of the CC

Acad Radiol 2012; 19:512–517

From the Department of Neurosurgery (M.Z., Z.L.), and the Department of Neurology (X.W.), The First Affiliated Hospital of Harbin Medical University, Harbin, Heilongjiang Province, China; Bio-X Center, Harbin Institute of Technology, Harbin, China (W.G.); and New York University Langone Medical Center and School of Medicine, New York, New York (C.S.). Received November 22, 2011; accepted January 5, 2012. This work was supported by grants 81071215, 81171304, and 81071219 from the National Natural Science Foundation of China and grant D201062 from the Science Foundation of Heilongjiang Province. Additional support was provided by grants P50 AG05681, P01 AG03991, R01 AG021910, P50 MH071616, U24 RR021382, and R01 MH56584 from the National Institutes of Health (Bethesda, MD). Drs Zhu and Gao contributed equally to this work. **Address correspondence to:** Z.L. e-mail: linzhiguo@sohu.com

©AUR, 2012
doi:10.1016/j.acra.2012.01.006

might already be present in the early stage of AD. Although much attention has been paid to heterogeneous AD groups, there are few studies on homogeneous AD groups (eg, patients with mild or moderate AD).

Homogeneous AD groups can be subdivided in terms of the Clinical Dementia Rating (CDR) (18), which is a numeric scale used to quantify the severity of the symptoms of dementia. A CDR of 0 indicates no dementia, and CDRs of 0.5, 1, 2, and 3 represent very mild, mild, moderate, and severe dementia, respectively. To our knowledge, no study has investigated callosal change on the basis of the CDR, especially for CDR 0.5 (very mild dementia) and CDR 1 (mild dementia). Patients in these two stages are more likely to progress to severe dementia. In this study, we investigated callosal change in these two stages to determine (1) when callosal atrophy can be detected and (2) how the CC changes.

MATERIALS AND METHODS

Subjects and Imaging Data

Data used in this study were obtained from the Open Access Series of Imaging Studies (OASIS) database (http://www.oasis-brains.org). The OASIS provides MRI data sets of the brain to the scientific community freely. The CDR, incorporating multiple cognitive and functional domains, was used to quantify dementia severity for participants. CDR 0 indicated no dementia, while CDR 0.5 and 1 represented very mild and mild dementia, respectively. For each subject, T1-weighted magnetization-prepared rapid gradient-echo images were acquired using a 1.5-T Vision scanner (Siemens Healthcare, Erlangen, Germany) (repetition time, 9.7 ms; echo time, 4 ms; flip angle, 10°; inversion time, 20 ms; delay time, 200 ms; resolution, 256 × 256 [1 × 1 mm]). Detailed selection procedures and characteristics of the participants were described by Marcus et al (19).

Because the patients with dementia were aged >60 years, we selected healthy controls aged >60 years to match the case group. All subjects were divided into three groups: those with very mild dementia (CDR 0.5; $n = 70$), those with mild dementia (CDR 1; $n = 28$), and healthy controls (CDR 0; $n = 98$).

Measurement of CC Atrophy

Semiautomatic segmentation of the CC. The CC on the midsagittal plane was segmented using a semiautomated method with the software package NASP (20). First, the midsagittal plane was extracted from the magnetic resonance volume using the method proposed by Hu et al (21) (Fig 1a). Assuming that the intensity distribution in the CC was approximately Gaussian, we determined the upper and lower thresholds of the CC using Gaussian mixture modeling (22) (Fig 1b). Then, a binary image containing several regions (include the CC) was obtained with dual-threshold segmentation (Fig 1c). Then, the boundary rectangle and its major and minor axes of each region were calculated using the method proposed by Chaudhuri and Samal (23). We also calculated other geometric measurements (ie, the length along the major axis, the width along the minor axis, the angle between major axis and the horizontal axis, and the area). The region of the CC was selected according to its anatomic characteristic: (1) length (from the anterior point to posterior point) of 7 to 9 cm, (2) width (from the superior point to the inferior point; Fig 1c) of 2 to 4 cm, (3) orientation (angle of the major axis with respect to the horizontal axis) from 5° to 40°, and (4) area >2 cm^2.

Because of the existence of noise in magnetic resonance images and variability of the anatomy, missegmentation or oversegmentation may take place in some magnetic resonance volumes. These flaws were amended by two raters mutually and manually using NASP, which also provides the function of manual delineation.

Division of the subregions of the CC. The CC was automatically divided into five subregions according to a modification of the Witelson partitioning scheme (24,25). Radial dividers emanated from the midpoint on the lower side of the bounding rectangle with equal angular interval, and the CC was subdivided into the rostrum and genu (CC1), the rostral body (CC2), the midbody (CC3), the isthmus (CC4), and the splenium (CC5), respectively (see Fig 2). The total CC area and each subregional area were calculated by multiplying the number of pixels and the pixel size automatically.

Statistical Analysis

Data distributions were assessed, and descriptive statistics were computed. Differences in the total CC area within groups were assessed using analyses of covariance, while three-way repeated-measures analyses of covariance were performed to assess the subregion differences within the three groups. Head size, as estimated by total intracranial volume, was used as a covariate in the analyses. Univariate orthogonal contrasts were further examined using post hoc pairwise comparisons to test for differences in subregions among groups. All the statistical computations were performed using SPSS release 13.0 (SPSS, Inc, Chicago, IL).

RESULTS

Interobserver and Intraobserver Variability

To evaluate the intraobserver and interobserver agreement of measurements, two experts were asked to segment the CC in MRI scans of 40 subjects using NASP. Each expert segmented the CC only two times within 2 weeks to avoid previous bias. Pearson's correlation coefficients for the total and subregional areas of the CC were very high, ranging from 0.931 ($P < .001$) to 0.954 ($P < .001$). For repeated segmenting of the CC by one observer, measurements were highly reproducible, with correlations between 0.956

Download English Version:

https://daneshyari.com/en/article/4218784

Download Persian Version:

https://daneshyari.com/article/4218784

Daneshyari.com