Comparison of Ictal-Interictal Subtraction and Statistical Parametric Mapping in Patients with Temporal Lobe Epilepsy

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ABSTRACT

The aim of this study was investigate the epileptogenic zone in temporal lobe epilepsy (TLE). We evaluated the subtraction image of interictal SPECT from ictal SPECT coregistered to 3-dimensional (3D) MRI, and compared with the normal healthy SPECT using a SPM99. Forty-nine patients with TLE (M:F=28:21, mean age: 33±2.1 years) underwent a pairs of ictal and interictal SPECT. We performed subtraction interictal SPECT from ictal SPECT in TLE patients. In addition, using SPM methods and t-statistics, SPECT images of the TLE patients were compared with normal healthy SPECT on a voxel by voxel basis. The voxels with a p-value of less than 0.05, 0.005, 0.001 were considered to be significantly different. The subtraction results by ictal and interictal SPECT coincided with the significant rCBF changes when compare of the normal healthy SPECT using a SPM99. The results suggested that analysis of difference of the two methods using healthy normal SPECT with SPM99 is useful tool in evaluation of seizure focus in epilepsy.

Keywords: Ictal SPECT, temporal lobe epilepsy

1. INTRODUCTION

Single photon emission computed tomography provides important clinical information measuring regional cerebral blood flow changes in the evaluation of epileptogenic focus. In general SPECT image has showed hyperperfusion in the epileptogenic region in ictal SPECT and hypoperfusion in interictal SPECT. Almost all analytical methods including the subtraction of the ictal and interictal images, and subtraction ictal SPECT registered to magnetic resonance image have increased diagnostic yield. Statistical parametric mapping is an increasingly established of neuroimaging analysis to localize statistically the significant changes in spatially normalized images on a voxel by voxel basis. The purpose of this study was to analysis of correlation the result of ictal-interictal difference and compare of normal SPECT that assesses the statistical significance of cerebral blood flow changes on a voxel by voxel in temporal lobe epilepsy patients.

2. MATERIALS AND METHODS

2.1. Patients

This study included 49 patients with epilepsy who were retrospectively selected from the patients who underwent the surgery treatment for epilepsy at the Asan Medical Center. All patients had video EEG monitoring for ictal and interictal SPECT scan performed. The patients ages range from 11 to 52 (mean age: 33 years, Female: 21, Male: 28). Healthy normal control subject's images were obtained from a database with brain perfusion SPECT

2.2 Data acquisition

All patients underwent ictal and interictal SPECT as a radiotracer 740-925MBq of tecnetium-99m ethyl cysteinate dimmer ([ECD] Neurolite; DuPont Pharma, North Billerica, MA) intravenous injection. Projection data were acquired on a triple head gamma camera; Triad XLT (Trionix Research Lab., Cleveland Twinsburg, OH, U.S.A) mounted with high resolution fan beam collimators. The camera was operated in the step and shoot mode with acquisitions at 3degree intervals sixty frame. Individuals were injected intravenously with of 740-925MBq of tecnetium-99m ECD in a quiet and dim room. Data was stored on a computer in a 128 x 128 matrix. The energy window was set at 140 keV with a 20% width. SPECT image reconstruction was performed using filtered back projection with SUN Workstation(SUN SPARC 20, SUN Microsystems, Silicon Valley, Ca. USA). Image smoothing was accomplished with a Butterworth filter, cutoff frequency 0.4 cycles/pixel. Raw images were reconstructed in 128 * 128 pixel axial planes with 3.89 *3.89 mm pixels and a 3.89mm slice thickness.

2.2.1 Ictal – interictal difference
To obtain the difference between interictal and ictal SPECT, interictal SPECT images were first subtracted from ictal SPECT images. Each voxel value of this subtracted image was then divided by the mean voxel value of the interictal SPECT. The result was represented as a percentage of cerebral perfusion variation relative to the interictal SPECT.

2.2.2 Fusion of MRI and difference SPECT image
In this study is include positive and negative variations and fused image on the T1 template MR image. These results were displayed as transverse, sagittal and coronal slices with a hot color for hyperperfusion result and winter color map for hypoperfusion. The Fusion image of MR and SPECT were displayed 2mm slice thickness sectional images.

2.3. Ictal – normal subject difference image analysis
SPECT images were analyzed using SPM 99 (Statistical Parametric Mapping 99, Institute of Neurology, University College of London, UK), implemented using Matlab (Mathworks Inc., USA). Prior to the statistical analysis, all the images were spatially normalized into SPECT standard templates to remove inter-subject anatomical variability. Affined transformations were performed to determine the 12 optimal parameters with which to register the brain on the template. Subtle differences, between the transformed image and the template, were mitigated using the normalization method. Spatially normalized images were smoothed by convolution, using an isotropic Gaussian kernel with 12-mm FWHM. The count of each voxel was normalized to the total count of the brain with proportional scaling in SPM, to remove the differences of global CBF between the individuals. After spatial and count normalization, significant differences between Ictal and ten normal subjects SPECT were estimated at every voxel using t-statistics.

2.4. Statistical parametric mapping
All SPECT data was transferred to the Analyze (Mayo Foundation, Baltimore, Md. USA) header format because of SPM 99 analysis. The header format of the SPECT data is 1Kbyte, x,y,z pixel size [79 95 68]. The SPECT images of the normal group and the paired of interictal and ictal SPECT of the patients were separately registered to MR template, to remove variations due to different size and shape of individual brains then compared with seizure focus and focus size. Statistical analysis was performed to compare the individual ictal scan with the mean ten normal SPECT image, and the individual ictal scans with the mean images of the corresponding interictal result. The resulting set of voxel values for each contrast constitutes a statistical parametric map of the t statistic, SPM{t}. The SPM{t} data sets were transformed to the unit normal distribution SPM{Z}with threshold at p value 0.05, 0.005, 0.001. The significance of each region was estimated using distributional approximations from Gaussian fields. The T1 weighted MR images were used as a guide for the transformation of all subject's SPECT images into the Talairach space and co-registration with the SPM package.

3. RESULTS

Ictal-icterictal SPECT difference imaging were compared with results obtained from SPM analysis of the same SPECT scans. Ictal SPECT image is hyperperfused temporal lobe compared with both normal SPECT and subtracted from ictal to interictal SPECT. The hyperperfusion was greater at a lower threshold ($P<0.05$, threshold $T= 1.83$) than at a higher threshold ($P<0.005$, threshold $T=3.25$, $P<0.001$, threshold $T=4.30$). When the ictal images were compared with the group of normal SPECT at a corrected P value of 0.05(Fig. 1B), showed a similar pattern of blood flow change and correctly lateralized. The result of the subtraction method that is subtraction image of interictal SPECT from ictal SPECT coregistered to 3-dimensional (3D) MRI(Fig. 2B), was showed upper and lower threshold level. Two thresholds levels are 15% and 50% of the maximum counts. To obtain the difference between interictal and ictal SPECT, interictal SPECT images were first subtracted from ictal SPECT images. But above all, global count normalization is preceded by interictal SPECT image. Differences in global activity between scans were removed by proportional mean scaling with the 50 ml/dl/min scan value calculated in SPM99. Global count normalization image is display on the Fig. 2A. Each voxel value of this subtracted image was then divided by the mean voxel value of the interictal SPECT. The result was represented as a percentage of cerebral perfusion variation relative to the interictal SPECT. It is generally identified same region that either subtraction from ictal to interictal or compared with the group of normal SPECT using a SPM99.

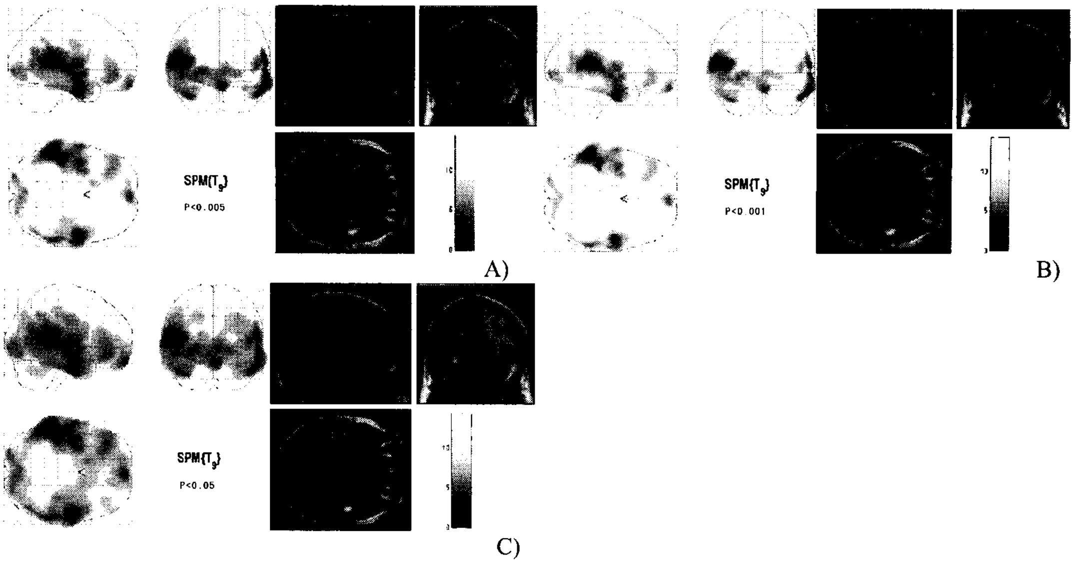

Figure 1. Compared with the temporal lobe epilepsy and the normal SPECT group ($P<0.05$). A) $P<0.01$ threshold $T=4.30$ B) $P<0.005$, threshold $T=3.25$ C) $P<0.05$, threshold $T= 1.83$.

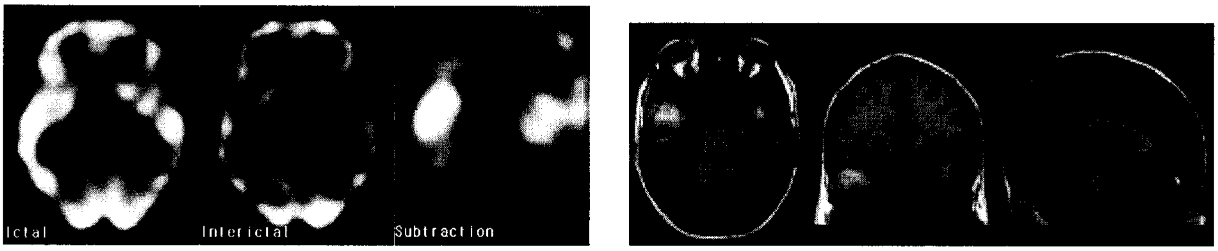

Figure 2. To obtain the difference between interictal and ictal SPECT, interictal SPECT images were subtracted from ictal SPECT images. Each voxel value of this subtracted image was then divided by the mean voxel value of the interictal SPECT. The result was represented as a percentage of cerebral perfusion variation relative to the interictal SPECT and then registratered on the MR image. A) Images of representative ictal, interictal and subtraction image. B) Image registration on MR with subtraction image.

CONCLUSION

The result of this study is the marked concordance between ictal-interictal subtraction SPECT imaging and compare with ten normal subjects SPECT using SPM analysis. The functional changes observed predominantly the temporal lobe but spread further out depend on p value. The concordance between SPM analysis and ictal-interictal subtraction SPECT is significant at p value 0.05. These studies were performed to assess the reliability of using a method of statistical analysis applied to SPECT imaging in the lateralization of seizure foci. Difference analysis using normal SPECT data with SPM could usefulness in the evaluation of seizure focus in temporal lobe epilepsy.

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