行政院國家科學委員會補助專題研究計畫成果報告

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以功能性磁振造影及數位化腦波研究半球性中風之橫貫大腦半球之跨越性功能障礙

Transhemispheric diaschisis in hemispheric stroke – An approach combing functional MRI and quantitative EEG

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計畫類別：▒個別型計畫　　□整合型計畫

計畫編號：NSC89－2314－B－002－125

執行期間：88 **年**　08 **月**　01 **至**　89 **年**　07　**月**　31　**日**

計畫主持人：邱銘章

執行單位：台大醫學院神經科

中　華　民　國 90　**年** 3　**月** 22　**日**

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一、中文摘要

本研究應用量化腦波及磁振造影的技術，來研究中風後橫貫半球之跨越性功能障礙的現象。由於此種現象是一種功能障礙，我們將重點放在功能上的測量。

病人在急性期（中風 72 **小時內）及亞急性期(中風** 2-3 **週後)各接受一次評估與檢查。評估的量表包括加拿大神經學量表，在亞急性期再加上巴氏指標之評量。**

磁振影像包括結構影像與及功能性影像。量化腦波一共記錄 2 **次，結果針對各大腦半球跨頻譜**(Crossspectral)**連貫性**(Coherence)**分析研究。**

總結：由於功能性磁振造影的敏感度與特異性在本研究中皆不理想。量化腦波的大腦半球跨頻譜(Crossspectral)**連貫性**(Coherence)**分析研究，則顯示了橫貫半球之跨越性功能障礙的現象。**

關鍵詞：橫貫半球之跨越性功能障，腦波連貫性分析，功能性磁振造影

Abstract

In this study we applied techniques of Quantitative EEG (qEEG) and MRI on the study of diaschisis after stroke. Since diaschisis indicates a remote change in functional status. Therefore, studies capable of measuring functional activities were adopted. We examined patients at acute stage (within 72 hours after stroke) and at subacute stage (after 14 to 21 days). The patients were also assessed with the Canadian Neurological Scale (CNS) in the acute stage and the CNS and Barthel index at the subacute stage. Structural MRI was be used to define the area and the extent of the stroke. Functional MRI acquired from GRE-EPI pulse sequence. The results from fMRI studies were not sensitive and specific enough for delineating the phenomenon. On the other hand, the qEEG study based on crossspectral coherence analysis revealed the diaschisis effect and its evolution over time, from acute to subacute stage.

Keywords: Transhemispheric Diaschisis, Coherence EEG Analysis, functional MRI

二、緣由與目的

Diaschisis is the remote changes in electric activity, blood flow, and metabolism[1] resulted form stroke in the contralateral hemisphere, subcortical region of the overlying ipsilateral hemisphere or in other remote region such as in the famous cases of crossed cerebellar diaschisis (CCD). The issue of diaschisis has been studied extensively but unfortunately, most of them are indirectly. The approach included investigation using PET[2] and TC-99m-HMPAO SPECT[3]. The PET scan may disclose regional oxygen consumption (CMRO2) and the SPECT for regional blood flow (r-CBF). Electrophysiological evidence of diaschisis was also demonstrated in either human study[4] or animal experiment[5]. The electrical diaschisis phenomenon in the acute stage of stroke may indicate on one hand the decrease of function[4], in terms of decreased alpha peak frequency and power, and on the other hand hyperexcitability in the paired-stimului model[5]. The CCD has been studied both in the cerebral infarct[6,7] and in cerebellar infarct[8]. The CCD effect studied by r-CBF study with TC-99m-HMPAO SPECT demonstrated that the functional and anatomical connection between the cerebellum and cerebral hemisphere were so important. That CCD may have a profound and an extensive effect on the neuropsychological and even language function. About the transcortical or interhemispheric diaschisis the result was more controversial[9-11]. Therefore it is the purpose of this study to investigate this phenomenon through clinical and electro-physiological approaches.

三、方法

Cross-spectral analysis is an important tool of EEG spectral analysis. It offers quantification of the relationship between different EEG signals in various counterpart location. The cross power Cxy(f) is the product of the smoothed Fourier transform of one signal and the complex conjugate of the other[12]. Therefore Cxy(f) is a complex quantity with a magnitude and phase.

$$Cxy(f) = |Cxy(f)| \exp[j\Phi xy(f)] \quad \ldots(1)$$

Φxy(f) is the phase spectrum. **Thus we can define a normalized quantity i.e., the coherence function as follows:**

$$Coh_{xy}(f) = \frac{|C_{xy}(f)|^2}{P_{xx}(f)P_{yy}(f)} \quad \ldots(2)$$

The analysis was performed on "Sensa" software of the Harmonie system (Stellate corp., Montreal, Quebec, Canada).

The cross spectral analysis was performed with paired-electrodes of the counterpart location from either hemisphere including F4/F3, C4/C3, P4/P3, O2/O1, F8/F7, T4/T3 and T6/T5. Comparison of the signals from two recordings of the EEG was done.

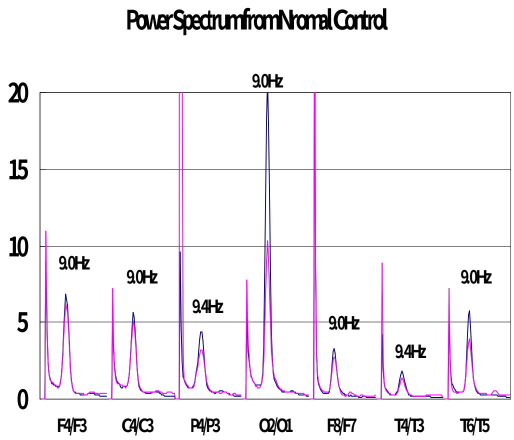
Spectral analysis was performed by applying Cosine FFT computation, the epoch for FFT was 2.56 seconds with 50% of overlap, multiple epochs of artifact free (e.g., eye blinks) was sampled.

四、結果與討論

The stroke scales (CNS) were 5±2 in acute stage and 7.1±1.1 at the subactue stage while the Batehl index was 68.1±26.1 (n=14). No significant correlation between the scores of the CNS at the acute stage and the Bathel ($r=0.35$, $p > 0.05$) while the subacute scores did ($r=0.47$, $p < 0.05$). The scores of the CNS in acute and subacute stages correlated well with each other ($r=0.71$, $p < 0.01$) and were different at the significance level of $p < 0.0001$. There were also 12 normal control included in this study. In the functional MRI tasks 8 normal controls and 7 patients were investigated with either motor or sensory stimulation. In normal group the motor fMRI showed consistent responses in the contralateral motor cortex and occasional simultaneous response in the ipsilateral cortex. In the patient group, most of them were hemiparetic and were not able to perform continuous hand movement through out the study. For the sensory study, electrical stimuli were applied to the median nerve of either hand during the examination. There were some minimal signal changes (0.2 to 1.8 %) in the contralateral sensory cortex related to the stimulation but the results were not so consistent even in the control group. Therefore, the results from the fMRI were not included for further analysis.

The power spectrum of the normal control (n=12) was showed in Figure 1, which was displayed with paired electrodes in counterpart location in either hemisphere. The peak frequencies were 9 Hz in most location and 9.4 Hz in parietal and temporal regions.

<u>Figure 1</u>



The coherence analysis of the normal control showed good coherence through out different locations. The coherence is greater than 30% in all location and in almost all frequencies under investigated (1-25 Hz). In lower frequencies, for example the á range, the coherence is above 50% to 60% and may be up to 70% or 80% in peak frequencies (Fig. 2).

The spectral analysis of individual patient at times revealed some interesting findings. For example, the power-spectral plot in one case (Case 5) showed crossing of the frequency profiles of EEG signals from two cerebral hemispheres (Fig. 3).

Figure 2

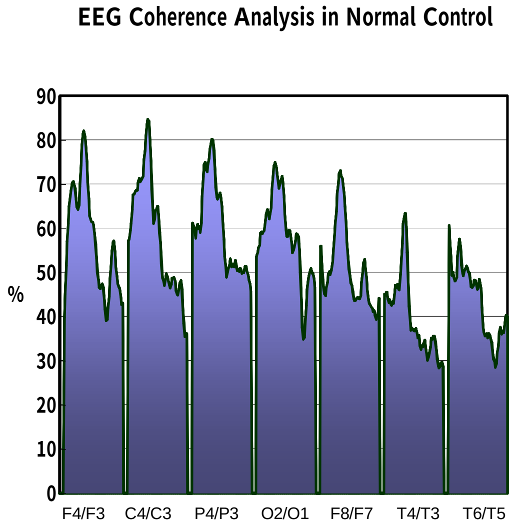
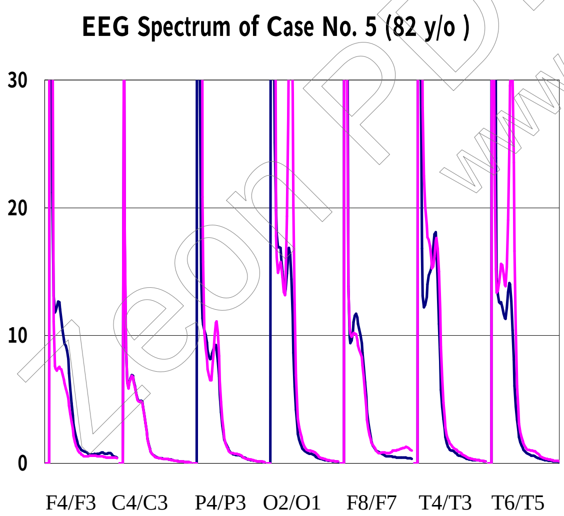


Figure 3

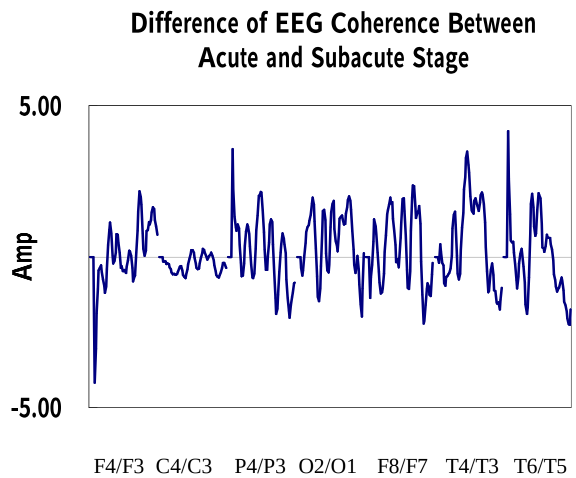


In Fig. 3 the red curve indicated the lesion side, which was the left hemisphere of this patient and the blue one indicated sound side, i.e., the right hemisphere. The blue cures were higher in amplitude in higher frequencies (á range) and lower in lower frequencies (è range).

The peak frequencies of the patient group in two occasions of the EEG acquisition were also measured and analyzed. The only significant correlation through out the peak frequencies and the stroke scales or Bathel index was that the peak frequencies of the lesion side at subacute stage correlate well with the CNS scores at subacute stage ($r=0.4$, $p < 0.05$). This could be understood. Since the disability might be brought about from some subcortical lesion, which might not be readily accessed by EEG especially in the acute stage. The peak frequencies changed in either hemisphere evolving from acute to subacute stage (sound side 0.02 ± 0.77, lesion side 0.18 ± 0.56). Neither reached statistic significance. This might imply that the peak frequencies themselves are not sensitive enough to describe the phenomenon of diaschisis.

On the other hand, the coherence analysis provided a more sensitive measure for the phenomenon of diaschisis. In contrast to the EEG coherence of the normal control, the patient group showed much lower coherence (less than 20%) in almost all positions except in the occipital and central regions. The reason may not be all clear but probably indicates that in the acute or subacute pathological conditions there are probably a subcortical mechanism leading to a hyper synchronous in the central (vertex) and occipital (projection from the thalamus) regions. Subtraction of the acute coherence by the subacute coherence from the patient group showed the evolution of the EEG in terms of frequencies and locations (Fig. 4).

Figure 4



In Fig. 4, the difference of coherence showed positive in lower frequencies level and some negative in higher frequencies range such as theta and slowá ranges. This might imply the evolution from acute to subacute stages demonstrating the reduction of the lower frequencies (slow waves in the non-lesion hemisphere) and increment in higher frequencies in either hemisphere especially the non-involved one.

In conclusion, in this study we found that EEG coherence is capable of detecting and demonstrating the functional changes of the cerebral hemisphere, which occurred during the cerebral vascular accidents. The sensitivity is better than simply computing the spectral of the EEG.

五、計劃成果自評

In our project, we were able to demonstrate the diaschisis of the human brain during the acute stroke through the functional measurement by using EEG coherence analysis. However, the fMRI approach at this moment was not yet an stable and consistent measurement for us.

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