

The Classification of In Vivo Proton Magnetic Resonance Spectroscopy of Brain Abscesses Using Principal Component Analysis (PCA)

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Introduction

Proton magnetic resonance spectroscopy (MRS) has been recognized as a powerful tool in diagnosis of brain tumors [1]. Recently, the interest in using proton MRS to identify the bacteria in pyogenic brain abscesses has been arising [2]. In this study, we propose an algorithm using principal component analysis (PCA) to differentiate anaerobic and aerobic abscesses by means of in vivo short TE proton MR spectra.

Materials and Methods

All experiments were conducted on a 1.5T MR system (General Electric, Milwaukee, WI) with quadrature coil. A total of 8 normal volunteers (all males, age range: 23-27 y/o), 8 patients of anaerobic brain abscess (6 males and 2 females; age range, 40-80 y/o) and 8 patients of aerobic brain abscess patients (4 males and 4 females; age range, 2-82 y/o) were included in our study. T1-weighted images or contrast-enhanced T1WI (for patients) were performed before single voxel spectroscopy acquisition to facilitate the localization of SVS voxel. Routine SVS PRESS protocol was conducted accordingly with parameters: TR/TE = 1600/35 ms, Ave = 128 for normal volunteers and 192 for patients, voxel size = 2x2x2 cm³.

Figure 1 shows the flow chart of the complete process procedure. The acquired MRS raw data (P-file) was underwent eddy current correction [3] before doing fast Fourier transform (FFT). The corrected spectra were then firstly normalized and scaled by unsuppressed water signal individually. Figure 2 demonstrates the corrected, normalized spectra of one normal volunteer (Fig. 2A), one anaerobic abscess patient (Fig. 2B) and one aerobic abscess patient (Fig. 2C), ranging from 0.5-4.2 ppm. Before applying PCA to these spectra, all these data were adjusted to become zero mean [4] and only data ranging from 0.5 to 4.2 ppm (196 points in our case) were analyzed by PCA. Eigenvectors generated by PCA were finally compared and two principal components (PC) were selected accordingly to differentiate three various groups of spectra.

Results and Discussions

Figure 3 shows two most significant PCs according to the eigenvectors by PCA. Spectra of normal volunteers can be easily distinguished apart from those of abscess patients. Most of the spectra from aerobic abscess patients can be identified successfully from anaerobic abscess patients. Yet 3 of aerobic abscess patients shows overlapping with 2 of anaerobic abscess patients. This may be solved by observing other PCs for more information. On the other hand, it may also result from the partial volume of a mixture of obligate and facultative anaerobes in the abscess tissue, which needs further detailed diagnosis.

Our preliminary result shows PCA can be one potentially useful tool to distinguish various types of brain abscesses without any complicated post-processing algorithm. Sophisticated post-processing algorithms, e.g. baseline correction, might eliminate some information involved in baseline. Our processing scheme may provide more precise analysis for MRS especially when macromolecular or strong lipid play an important role of clinical diagnosis.

Reference

[1]Zhu XP. et al., *MRM*, 55, pp. 706-11, 2006. [2]Lai PH. et al., *AJNR*, 29, pp. 1511-8, 2008.
[3]Klose U, *MRM*, 14, pp. 26-30, 1990.
[4]Daffertshofer A. et al., *Clin Biomech (Bristol, Avon)*, 19, pp. 415-28, 2004.

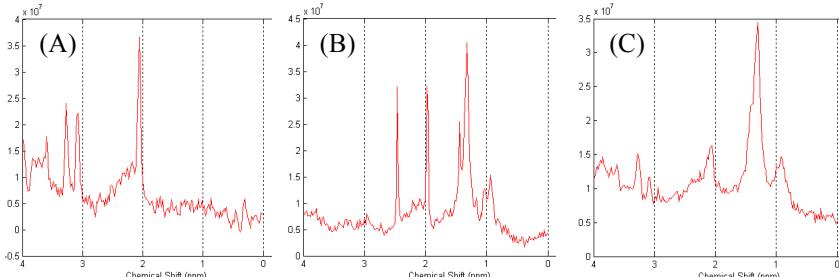


Figure 2. Eddy current corrected spectra from (A) normal volunteers, (B) anaerobic abscess patients and (C) aerobic abscess patients were prepared for PCA process.

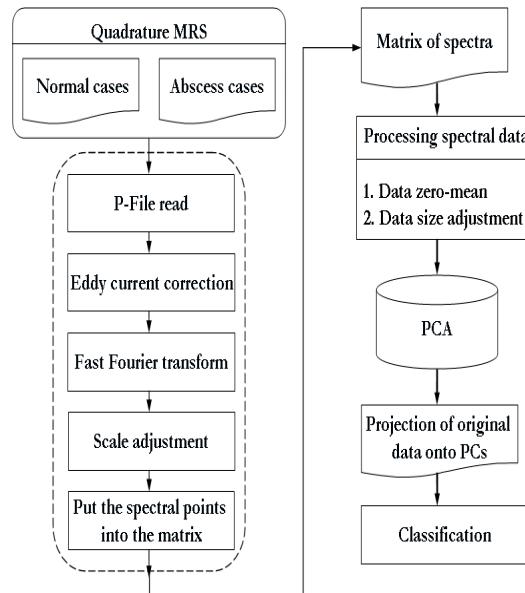


Figure 1. The flow chart of complete process procedure.

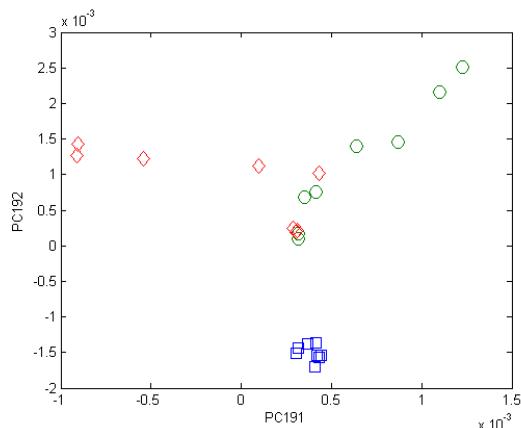


Figure 3. PCA result demonstrated by two most significant PCs: PC191 and 192. Data of normal volunteers (blue square), anaerobic abscess patients (green circle) and aerobic abscess patient (red diamond) can be classified easily.