Structural MRI-Based Radiomics and Machine Learning for the Classification of Attention-Deficit/Hyperactivity Disorder Subtypes

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INTRODUCTION

- Attention-deficit/hyperactivity disorder (ADHD) is a common disabling neurodevelopmental disease that can cause aberrant impulsive and hyperactive behaviors in children and adults.[1]
- ADHD includes ADHD combined (ADHD-1) type, ADHD inattentive (ADHD-3) type and ADHD hyperactive type. [2]
- Radiomics is a potential objective tool informing the subtyping of ADHD in clinical community. [3]

AIM

This study aimed to establish a machine learning model using the structural MRI-based radiomics features to separate the subtypes of ADHD.

METHOD

- This study collected 88 ADHD patients' MRI T1W1 data of New York University (NYU) Medical Center from the ADHD-200 Global Competition, including 56 with ADHD-combined type (ADHD-1) and 32 with ADHD-inattentive type (ADHD-3). [4]
- We performed image preprocessing, including image reconstruction, correction, registration and segmentation, using cat12 software based on SPM12 in Matlab 2013. The standardized gray matter (GM) images and white matter (WM) images were exported after the pre-processing was finished (Figure 1 and Figure 2).
- A total of 1057 radiomics features were extracted from the whole GM and the whole WM using IBEX source, respectively.
- The two-sided Wilcoxon rank sum test was used to calculate the differences between ADHD-1 group and ADHD-3 group; the features with $P < 0.05$ were selected for further analysis.
- We further selected the predictive features and classified the two groups using a sequential backward elimination support vector machine (SBE-SVM) algorithm. In this procedure, the 88 patients were divided into the training set (n = 56), the validation set (n = 7) and the test set (n = 25).

RESULTS

The structural MRI-based radiomics model was able to classify ADHD-1 and ADHD-3 (total accuracy: 84%; area under curve (AUC): 0.81; accuracy in ADHD-1 group: 93%; accuracy in ADHD-3 group: 70%) (Figure 3 and Figure 4).

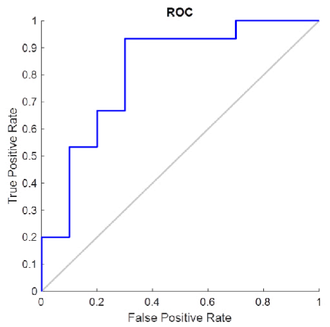

Figure 3. The receiver operating characteristic (ROC) curve for the classification of ADHD-1 patients and ADHD-3 patients.

This model finally selected one GM-based neighborhood intensity difference matrix (NIDM)-feature and 18 WM-based features, including 9 gray-level co-occurrence matrix (GLCM)-features, 8 first-order features and one NIDM-feature ($P = 0.003$-0.049). Figure 5 shows two WM-based radiomics features that were selected in the model.

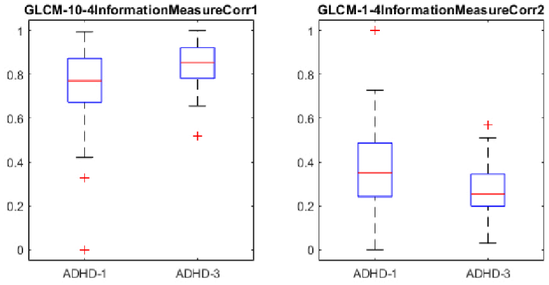

Figure 5. The boxplots for data distribution of 'GLCM-10-4Information measurement correlation 1' (left) and 'GLCM-1-4Information measurement correlation 2' (right).

Figure 1. The standardized white matter (WM) images that were segmented from MRI T1W1 images using cat12 software.

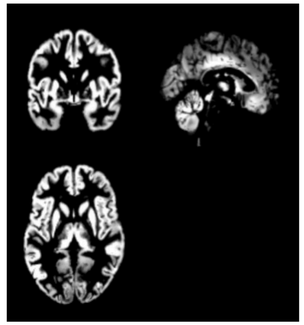

Figure 2. The standardized gray matter (GM) images that were segmented from MRI T1W1 images using cat12 software.

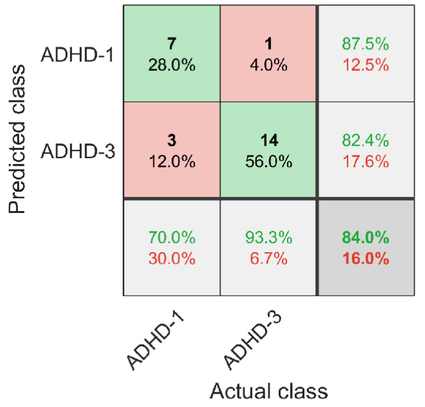

Figure 4. The confusion matrix for the classification of ADHD-1 patients and ADHD-3 patients in the test set.

CONCLUSIONS

- We demonstrate that combining radiomics features extracted from WM images and GW images that were segmented from structural MRI T1W1 images can distinguish ADHD-1 patients from ADHD-3 patients.
- The structural MRI-based radiomics may be the potential biomarker for the clinical subtyping of ADHD.

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