Application of machine learning on differential diagnosis of Narcolepsy subtypes using PET/MRI imaging

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Abstract:

Background*:* Narcolepsy is a central hypersomnia disorder, and differential diagnosis between its subtypes is sometimes not easy. Machine learning can regroup different factors to distinguish different subtypes and help clinicians to provide early treatment. Thus, we applied machine learning to analyze our positron emission tomography (PET) data of patients with narcolepsy type 1 and type 2, and aimed to construct predictive models to facilitate diagnosis.

Methods: This is a prospective case-control study of adolescent and young adult patients with narcolepsy type 1 and type 2. All participants received ^{18}-F-fluorodeoxy glucose (FDG) PET/MRI, sleep studies (actigraphy, polysomnography, and multiple sleep latency test), neurocognitive tests (continuous performance test and Wisconsin card sorting test), and sleep questionnaires. The collected data were analyzed by the feature selection method (multivariate minimal redundancy maximal relevance) to select fewer features as biomarkers and improve efficiency and accuracy in the differential diagnosis. Different machine learning methods were explored with selected features to construct predictive models, including logistic regression, Gaussian naive Bayes, stochastic gradient descent, K-nearest neighbors, decision tree, random forest, and supporting vector machine with radial based function kernel.

Results**:** A total of 308 participants were enrolled, 189 had narcolepsy type 1, and 119 had type 2. There was no significant group difference in gender, onset age, and current age, but there were significant differences in positive human leukocyte antigen (HLA) typing and mean sleep latency in MSLT.

We found 4 important features by the feature selection method, including the right thalamus, right mid orbital frontal, left calcimine, and right heschl. We used the set of four features as our comparative data for comparison of different machine learning methods. The accuracy of the supporting vector machine with radial based function kernel was 87.09%, and the sensitivity and specificity were 100% AND 89.76%. The fair accuracy was confirmed by other machine learning methods, and the accuracy of K-nearest neighbors, Native Bayes, Random forest, and Logistic regression were 82.8%, 84.76%, 87.09%, and 85.71% respectively.

Conclusion**s**: The accuracy, sensitivity and specificity of our predictive model by supporting vector machine with radial based function kernel are good, and the exploration by different machine learning methods confirmed the importance of the 4 selected features in differential diagnosis of narcolepsy subtypes. These findings have important value in distinguishing subtypes of narcolepsy and increasing our understanding of the pathophysiology of different types of narcolepsy.

Keywords: Narcolepsy, hypersomnia, PET study, machine learning, feature analysis