Prediction for cardiac prognosis in patients with congestive heart failure by machine learning on dual-isotope myocardial semiconductor SPECT

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Background: Dual-isotope (low doze 201TlCl and 123I-β-methyl-P-iodophenyl-pentadecanoic acid (BMIPP)) single photon emission computed tomography (SPECT) is utilized to estimate myocardial damage in patients with congestive heart failure (CHF). However, predictive model construction on the SPECT for cardiac death by machine learning was not studied.

Purpose: To elucidate predictive value of machine learning model on dual-isotope SPECT for CHF.

Methods: We enrolled consecutive 310 patients who admitted with CHF (77.1±3.1 years, 164 males). After initial treatment, they underwent electrocardiography gated SPECT and observed in median 507 days [IQR: 165, 1032]. Multivariate Cox regression analysis for cardiac death was performed, and predictive model was constructed by ROC curve analysis and machine learning (Random Forest and Deep Learning). The accuracies (= [True positive + True negative] / Total) of the prediction models were compared with ROC curve model.

Results: Thirty-six patients fell into cardiac death. Cox analysis showed Age, left ventricular ejection fraction (LVEF), summed rest score (SRS) of BMIPP, and mismatch score were significant predictors (Hazard ratio: 1.068, 0.970, 1.032, 1.092, P value: <0.001, 0.014, 0.002, <0.001, respectively). ROC curve analysis of them revealed the accuracy of the cut-off value was 0.479–0.773. Conversely, machine learning model demonstrated higher accuracy for cardiac death (Random Forest: 0.895, Deep Learning: 0.935). The top 4 feature importance of the random forest were LVEF (0.299), SRS BMIPP (0.263), Age (0.262), and mismatch score (0.160).

Conclusion: Machine learning model on SPECT was superior to conventional statistic model for predicting cardiac death in patients with CHF.

Accuracy of prediction model for cardiac prognosis in patients with CHF

	Accuracy
LVEF ≤44%	0.531
SRS BMIPP ≥27	0.764
Age ≥78 years	0.479
Mismatch score ≥13	0.773
Random Forest method	0.895
Deep Learning	0.935

Accuracy Improvement by Deep Learning
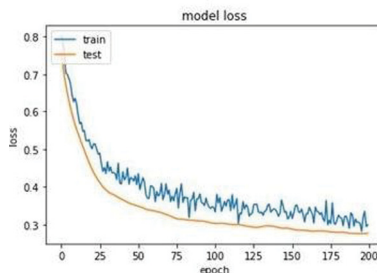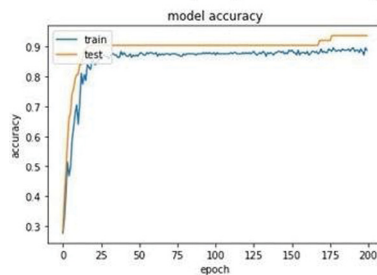
Deep Learning: Keras sequential model based on Python Program.

Hidden layers was 2, whose dimension were 20-10. Activation function was "relu".

Output layer was 1, whose activation function was "sigmoid".

As compiler, optimizer was "Adam", and loss was defined as "binary cross-entropy".

Training batch size was 50, and number of epoch was 200.

Accuracy of the prediction model was 0.935