Machine learning for identification of acute adverse reactions to iodinated contrast media using routine clinical and laboratory data in cancer patients

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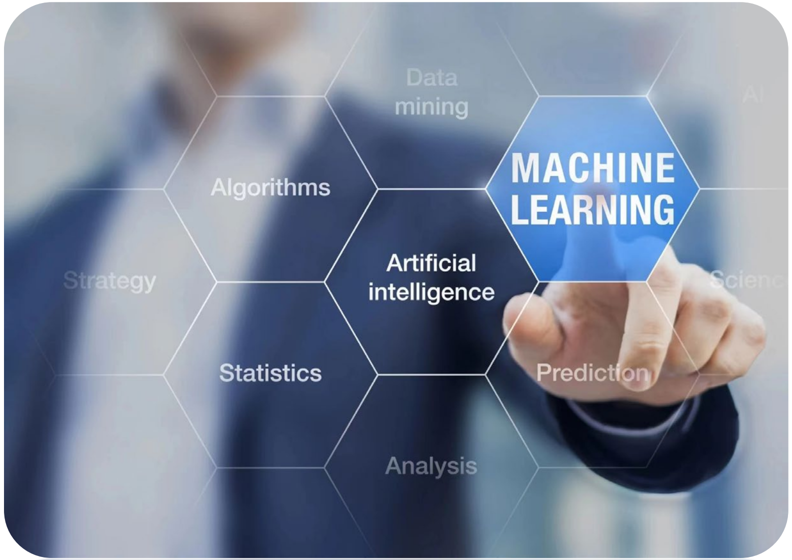
Introduction

Background: Iodine contrast medium is widely used in enhanced CT scans, but it can cause acute adverse reactions (AARs).There is no consensus on the incidence and risk factors of AARs, especially for cancer patients and no previous studies on using deep learning to predict AARs based on text data

Objective

Cancer patients undergo routine computed-tomography scans and iodinated contrast media (ICM) administration. This study was carried out to explore the risk factors of acute adverse reactions (AARs) associated with iodinated contrast media in cancer patients, to develop a prediction model based on routine clinical and laboratory data using machine-learning.



Methods - Data & Material

- ***Data collection***

Data sources: 208,035 enhanced CT examination data cases from Jan. 2019 to Dec. 2021

Data variables: Their demographic information, clinical and laboratory data, CT scan protocol and AARs of iodinated contrast media were collected.

Data quality: collected by two trained personnel and double-checked for accuracy

- ***Data preprocessing***

We cleaned and normalized the data and removed outliers. Features with high missing rate was removed and others imputed by mean value.

There were 510 cases with acute adverse reactions and 540 cases without AARs matched by PSM. and randomly divided into train set (848 cases) and test set (112 cases)

Methods - Model Training

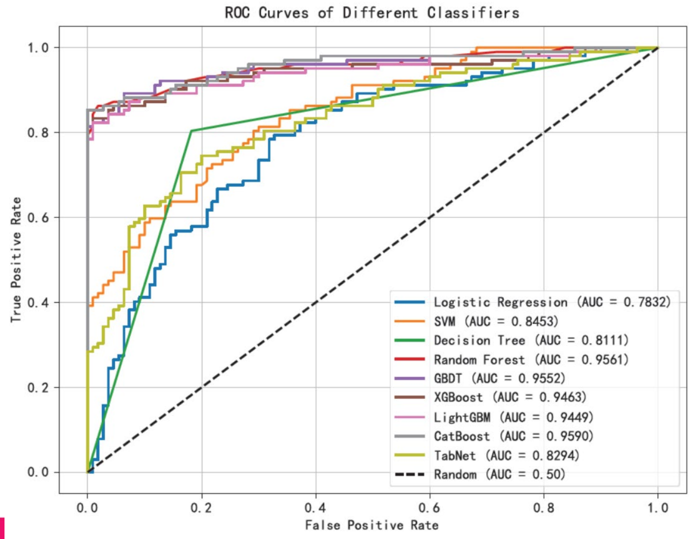
- ***Feature Extraction:*** We extracted features from the routine clinical and laboratory data associated with patient characteristics, and use the Pearson correlation factor for selection.
- ***Model selection:*** We use 9 selected machine learning methods varying from traditional models to novel models of ensemble learning and deep learning: ***logistic regression, support vector machine, decision tree, random forest, XGBoost, LightGBM, CatBoost, TabNet***.
- ***Model Training & testing:*** We split the data into 80% training set and 20% test set. We trained each model on the training set using GridSearch and 5-fold cross-validation for hyperparameter optimization. We tested each model on the test set using various metrics such as accuracy, precision, recall, F1-score, and ROC curve.

Results

- Total AARs Occurrence: 510 of 208035(0.245%), with mild 432 (0.207%), moderate 63 (0.030%), and severe 15 (0.007%).
- Novel machine learning methods especially a Catboost model outperform traditional methods such as LR.

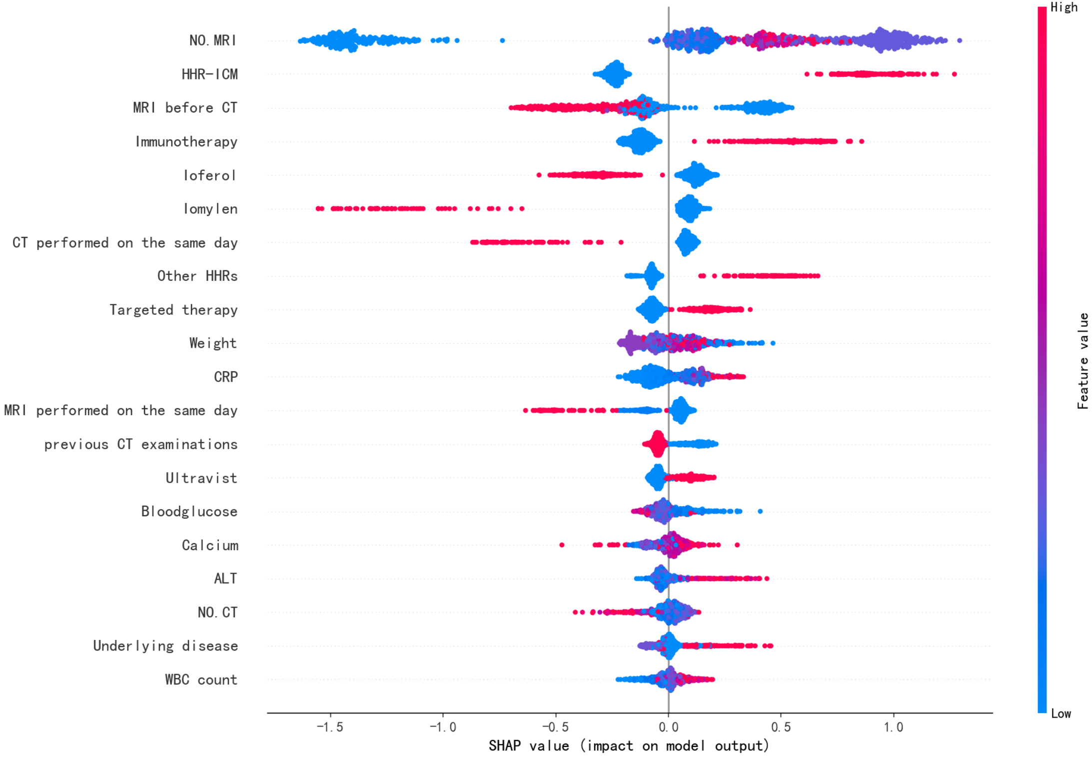
Table 1: Performance of different classifiers

Classifier	Accuracy (%)	Precision (%)	Recall (%)	F1 score (%)	AUC score (%)
Logistic Regression	71.23	73.03	63.73	68.06	78.32
SVM	74.06	75.82	67.65	71.50	84.53
Decision Tree	81.13	80.39	80.39	80.39	81.11
Random Forest	91.98	96.70	**86.27**	91.19	95.61
GBDT	90.09	95.51	83.33	89.01	95.52
XGBoost	90.57	95.56	84.31	89.58	94.63
LightGBM	90.57	98.81	81.37	89.25	94.49
TabNet	75.47	80.49	64.71	71.74	82.94
CatBoost	**92.92**	**100.00**	85.29	**92.06**	**95.90**



Results

- SHAP for model explanation to visually display feature importance.
- Several variates significantly associated with AARs were history of hypersensitivity reaction to ICM, immunotherapy, excessive MRI enhancement scan, ICM type



Limitation & Future works

- Collecting more data from different sources and domains to increase the coverage and diversity of AAR cases.
- Using a combination of methods or a hybrid method that can leverage the advantages of each method and overcome their limitations (but may also decreases the model interpretability).

Conclusion

- A machine-learning model was more accurate for predict the occurrence of AARs associated with iodinated contrast media, which can offer useful guidance to clinicians and patients for individually adjuvant therapy.

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