Application of artificial intelligence techniques in renal transplantation: classification of nephrotoxicity and acute cellular rejection

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Abstract and Objective

Complications associated with kidney transplant and immunosuppression can be prevented or treated effectively if diagnosed in early stages with post-transplant monitoring. One of the major problems is diseases during the first year of the transplanted kidney. To this purpose we used different classifiers to predict events of nephrotoxicity and acute cellular rejection. The classifiers were evaluated according to the value of sensitivity, specificity and area under ROC curve. The technique that had the best sensitivity rate prediction for the submission to the transplanted kidney biopsy was SVM (LIBSVM algorithm) with sensitivity rates of 0.87 (accuracy rate 79.86; specificity 0.70; AUC 0.79). A critical error is estimated in 7.5%. These results are encouraging with rates of trial and error consistent with work purpose. The purpose of this study is compare different artificial intelligence techniques in the prediction of events of nephrotoxicity and acute cellular rejection (ACR) in renal transplanted.

Keywords:

Organ transplants, Artificial intelligence, Kidney transplant, Clinical decision support system.

Methods

We divided our research in four steps: classifying stage, classifying validation stage, clinical decision support system (CDSS) validation stage, and deployment stage. In this paper we will discuss results of the first phase of our research. This work has been accepted by the ethics committees of UNIFESP (protocol number 2554/09) and CTCSE (protocol number 1677/08).

The classifying stage was divided in two classifiers phases: submission to the transplanted kidney biopsy phase and nephrotoxicity and ACR determination phase. Phase 1 is aimed at screening of suspected cases of nephrotoxicity and ACR to the transplanted kidney biopsy. Phase 2 is specific to predict which complication the patient has. In this stage data from 145 patients at Centro de Transplante da Casa de Saúde Santa Efigênia (CTCSE), Caruaru-PE, Brazil considering 20 attributes.

We used neural networks (ANN), support vector machines (SVM), decision trees (DT), bayesian inference, and nearest neighbors (NN), each one with many different parameters (neurons in hidden layer in ANN, gain ration in DT, number of neighbors in NN), to provide the best classifier to our problem. The classifiers were evaluated according to the sensitivity, specificity and area under ROC curve (AUC) value, using 10-fold cross validation of all initial database, and, to compare different classifiers we used the Kruskal-Wallis.

The classifying validation phase is being conducted, with patient data collected during the second semester of the year 2009 from CTCSE. The CDSS validation phase will evaluate the effectiveness of submission patients to biopsy with doctor using CDSS compared to other cases of the same doctor not using the system.

Results

The technique that had the best sensitivity rate prediction for the submission to the transplanted kidney biopsy was SVM (LIBSVM algorithm) with sensitivity rates of 0.87 (accuracy rate 79.86; specificity 0.70; AUC 0.79). The technique that had the highest AUC for predicting nephrotoxicity and ACR was bayesian inference (NaiveBayes), with AUC rates of 0.8 (accuracy rate 75.92).

By grouping these two classifiers we had estimated the accuracy in 67% and the critical error estimated in 7,5%. By critical error we assume that a patient is classified as having ACR or nephrotoxicity but doesn´t have a biopsy done.

Conclusion

The present results are encouraging, with rates of trial and error consistent with the determination of acute cellular rejection and nephrotoxicity.The initial methodological approach (without the division into two stages of classification) did not show satisfactory results. This result is related to the fact that the clinical manifestations of two complications are similar

and the attributes used to predict do not allow an accurate distinction.

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