A review: Prediction model for the incidence rate of intracerebral hemorrhage

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Abstract Intracerebral hemorrhage (ICH) accounts for around 10-30% incidence of the cerebral apoplexy, the prognosis of which is so poor that has high morbidity and mortality. In cerebral hemorrhage, the artery bleeding is very common. Along with the development of imaging, computed tomography angiography (CTA) can be used to predict the incidence of intracerebral hemorrhage. Based on the previous studies for ICH. This study proposed such a novel mathematical model for the incidence of cerebral hemorrhage prediction that not only investigated the potential risk factors ICH, but also employed CTA images and statistic test to explore which potential risk factors can be used as the classifier of the mathematical model. Next, we used training data set to train the weight of these selected risk factors by artificial intelligence algorithm as well as employed testing data to validate the predictive power of the model. We expected this mathematical model can be be able to predict the incidence rate of cerebral hemorrhage and offer the corresponding preventive suggestion in the distant future.

1. Introduction

Intracerebral hemorrhage (ICH) is an acute, spontaneous bleeding from the cerebral parenchymal blood vessels. Intracerebral hemorrhage accounts for 10% to 30% of cases of acute cerebral apoplexy. The case fatality rate of patients with intracerebral hemorrhage within one month is as high as30%~50%[1] and more than 30% of survivors survive with neurological dysfunction. Though the drug for cerebral hemorrhage and high blood pressure can significantly control the risk of the cerebral hemorrhage incidence, the clinical consequences of cerebral hemorrhage is very serious and the mortality rate of the patients with cerebral hemorrhage is still as high as 50%[2, 3]. However, the pre-diagnosis for ICH can effectively reduce the incidence rate of ICH [4, 5]. Therefore, this study purposes to develop such a mathematical model that can predict the incidence probability of ICH.

Currently, there are a lot of studies for the intracerebral hemorrhage pre-diagnosis. Especially, the research on the application of information technology for predicting the risk of cerebral hemorrhage incidence is comprised of two directions. One is to predict the incidence rate of intracerebral hemorrhage[3, 6-8]. For example, Capon et al.,[6] investigated the relationship between the seasons and cerebral hemorrhage, which demonstrated that the temperature could be used to predict the risk of cerebral hemorrhage. Ciccone et al.,[7] reported that the gender also affected the incidence rate of intracerebral hemorrhage. However, the predictive object of these research was based on a special group of people rather than the individual patient. And several important properties of the cerebral hemorrhage (such as blood

pressure) were not considered in the predictive model. The other direction is to predict ICH hematoma expansion[1, 5, 8-20]. For example, Wada et al.,[2] build up a prediction model by CTA "spot sign", which can predict hematoma expansion for individual patients. Nonetheless, CTA spot sign can't be applied to predict the probability of intracerebral hemorrhage directly as well as the model does not use training data to optimize its key parameters.

To overcome the shortcomings of the previous research [1-10, 13], this study put forward an improved algorithm to predict ICH. First, a set of statistical tests will be used to validate which potential risk factors suggested by the clinical personnel are statistically significant. And then, these validated risk factors will be employed as the classifiers to develop the predictive model. Next, artificial intelligence algorithm will be used to train the key parameters of the predictive model by fitting the simulated results against the training experimental data as well as using testing data compute the predictive power of the predictive model.

2. Marterial and Pre-research methods

Computed tomography angiography (CTA) is a rapid, noninvasive investigation for patients with ICH and it is useful for identifying potentially treatable entities such as aneurysms and other vascular lesions, which provides help and guidance for further clinical treatment [2]. The CTA images of this study come from the Third Military Medical University. The poor quality of the CTA images are excluded in the data preprocessing stage.

This research put forward a mathematical model (Fig. 1) to predict the incidence rate of intracerebral hemorrhage, which consists of three steps: (1) Data preprocessing, (2) feature selection and (3) model training and testing.



Fig1. The workflow chart

2.1 Data preprocessing

The rupture of lenticulostriate arteries is commonly occurred in intracerebral hemorrhage[21]. The diameter of the lenticulostriate arteries is tiny, generally less than 0.5 millimeter. Since not all of lenticulostriate arteries can be identified clearly in the CTA image, we have to choose the CTA images with clear lenticulostriate arteries from source CTA image set (Fig.2). Also, we sharpen the raw CTA image by Laplace sharpening method[22] to improve the image quality. Fig 3 shows that the sharpened CTA image is better than the original image (Fig. 2). Finally, we reconstructed CTA images to have Fig.4, in which the lenticulostriate arteries are circled too.



Fig 2. The raw CTA image and the red cvcle indicates the Lenticulostriate arteries



Fig 3. The CTA image after Laplace sharpening



Fig 4. Lenticulostriate arteries indicated by red cycle in the CTA reconstructed image

2.2 Feature selection

We chose the potential risk factors provided by the clinical personnel (such as glucose levels, blood pressure, the use of antihypertensive medication, blood vessel diameter, blood flow, and so on). And we extracted the values of these potential risk factors from the CTA images (such as diameter, density, area and so on). After that, a set of statistical tests are used to validate which features are statistically significant. Lastly, these statistically significant features are employed as the classifiers to develop the predictive model.

2.3 Model training and testing

After we selected the statistically significant features, we planed to employ several classical data mining algorithm such as decision tree[23], Bayes network[24] and supporting vector machine[25] to develop such a mathematical model that can predict the incidence probability of ICH. Before starting the model development, we will divide the CTA image set into the training and the testing data sets. The training data set will be employed to train the weight of the classifier of our predictive model. And the testing data set will be used to validate the predictive power of the mathematical model. Finally, sensitive analysis will be carried out to explore which parameters are the key parameters of the model.

3. Expected results and discussion

By the analysis of the human brain CTA Images, this study expects to build up such a mathematical model to predict the incidence probability of ICH. Data preprocessing expected to improve the CTA image resolution by the digital image processing and reconstructed CTA images for the further research. Feature selection employed statistic test methods to explore which risk features are statistically significant. Model training and testing step employed training data and data mining algorithm to optimize the key parameters of the model as well as used testing data to validate the predictive power of the model. Because of the high mortality and disability rate of cerebral hemorrhage, it is very important to pre-diagnosis and prevent intracerebral hemorrhage. Therefore, we expect to establish such a sufficiently accurate forecasting model

with respect to the artificial intelligence theory and CTA images that can not only predict the incidence of cerebral hemorrhage, but also provide the corresponding preventive suggestions.

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