

Risk Assessment for Acute Myocardial Infarction Patients Using Artificial Neural Networks

J Sepúlveda¹, E Soria¹, G Camps¹, G Sanz², J Marrugat³, L Gómez¹

¹Universidad de Valencia, Valencia, Spain

²Hospital Clinic, Barcelona, Spain

³Instituto Municipal de Investigación Médica, Barcelona, Spain

Abstract

The purpose of the present study was to develop a clinical score for risk assessment to determine the profile of every patient with acute myocardial infarction (MI).

A cohort of 1,318 consecutive patients with a first MI admitted to four referral teaching hospitals (one with tertiary facilities) were followed up for 6 months after admission. To classify patients an Artificial Neural Network (ANN), called Multilayer Perceptron was used with the backpropagation learning algorithm. This method is used to analyse a collection of simple clinical markers.

The model has achieved high values of sensitivity and specificity in the classification of the patients, training both in the training cohort (91.58% sensitivity, 79.37% specificity), and the validation cohort (88.46% sensitivity, 78.09% specificity).

The use of simple clinical variables allows ANNs to give a reliable prediction of risk for in-hospital and 6-month mortality.

myocardial event, but the efficacy of therapeutic intervention in acute myocardial infarction is strongly time dependent. The use of classification methods to predict prognosis, might, further decrease in-hospital mortality. The importance of risk assessment is due the variability in mortality risk, and the time dependence of the efficacy of reperfusion therapy among patients with MI. To allocate every patient to the most beneficial treatment, the risk profile of every single patient should be available immediately when a patient enters the medical care system. Careful risk assessment for each patient aids clinicians in assessing prognosis and may therefore be a useful guide in management, providing valuable information.

The purpose of the present study was to develop a clinical score for risk assessment to determine the profile of every patient with acute myocardial infarction (MI). The paper is organized as follows. In the next section methods are presented both the study design and variables. We go on by reviewing the MLP properties. In section III we present the results. In section IV we give the conclusions and a proposal for further work

1. Introduction

The prognosis of patients admitted for acuted myocardial infarction (MI) has progressively improved in the past 30 years [1]. However, despite the advances in the treatment of acute myocardial infarction (MI), there is high in-hospital mortality. The introduction into clinical practice of effective treatments, such as thrombolysis, aspirin, β -blockers, and angiotensin-converting enzyme ACE inhibitors [2-4], has changed the prognosis of the disease. More aggressive interventions, such as direct percutaneous transluminal coronary angioplasty (PTCA) might, for selected patients, further decrease in-hospital mortality [5]. Practitioners have a wide variety of reperfusion strategies, to interrupt the evolving

2. Methods

The RESCATE (Recursos Empleados en el Síndrome Coronario Agudo y Tiempos de Espera) study consisted of a registry of first AMI and UA patients admitted to one hospital with, and three others without, coronary angiography facilities or coronary surgery.

2.1. Study design

The study was designed as a 6-month follow-up study of patients admitted to one hospital with, and three without, angiography or coronary surgery facilities. All four participating hospitals were public teaching institutions. Only patients initially admitted to each of the

study hospitals were retained for analysis in the original hospital's cohort.

Inclusion criteria. Between May 1992 and June 1994, all patients with a first MI up to the age of 80 years admitted to the four participating hospitals within 72 h of onset of symptoms of MI were included. MI was diagnosed when two of the following criteria were present: 1) abnormal Q waves, 2) increase in cardiac enzyme levels (more than twice the upper normal value), and 3) typical chest pain >20 min in duration.

Exclusion criteria. Residence outside the study areas or any of the following condition: 1) life-threatening diseases other than the index event; 2) previous CABG or PTCA; 3) or coronary angiography in the past 6 months. Patients enrolled in ongoing clinical trials were not excluded to reproduce actual care scenarios more faithfully.

2.2. Study variables in acute phase of MI

The following variables were prospectively recorded by a trained investigator at each centre: demographic data; history of hypertension; diabetes; chronic obstructive pulmonary disease; peripheral vascular disease; smoking status; MI location; Killip Class; presence of severe arrhythmia (defined as the occurrence of at least one episode of ventricular fibrillation or sustained ventricular tachycardia requiring immediate medical intervention) within the first 72 h; delay from onset of symptoms to first monitoring in a emergency room, coronary care unit or general intensive care unit; and hospital stay, use of thrombolysis, exercise test, coronary angiography, percutaneous transluminal coronary angioplasty and coronary artery bypass graft surgery and the complications associated with diagnostic and therapeutic procedures.

2.3. The Multilayer perceptron

To classify patients the familiar Multilayer Perceptron was trained with the backpropagation as learning algorithm. This method is used to analyze a collection of simple clinical markers. The neural model uses several units, called neurons, whose structure is shown in Fig. 1.

A neuron has the following elements:

- **Synaptic weights**, which are updated with the learning algorithm.
- **Adder**, all the inputs multiplied by their weights are added.
- **Activation function**, a non-linear function. Several activation functions can be used, however, in the current study we have used the hyperbolic tangent.

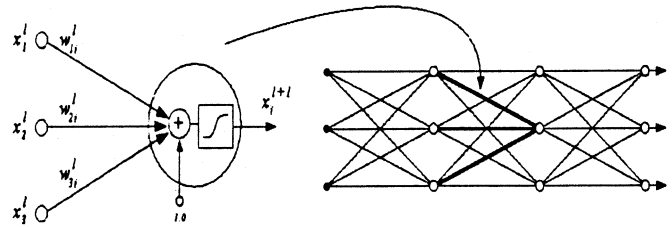


Fig1. Perceptron Neuron.

The multilayer perceptron uses several neurons in a multilayer structure. In this structure, the output of the neurons in one layer is, in turn, the input of the neurons in the following layer; no direct connection between neurons in non-consecutive layers and no feedback has been considered. *Backpropagation* was the learning algorithm used to train the neural network. This technique has to minimize a monotonic increasing function of the network error. In order to get good generalization levels, the training algorithm was stopped using the cross-validation criteria [6].

Using the back-propagation learning algorithm several problems were found and are described below.

Local minimum. The back-propagation algorithm searches for the closest minimum value in the error surface adjusting the weights using some gradient descending method. This adjustment is done using the inverse direction of the gradient of the error surface curve. The problem arises because this curve may have more than one minimum and the adjustment starts over a local minimum instead of the desired global minimum.

Saturation. The activation function works on its extremes causing the learning algorithm to stop. This problem can be solved using a smaller target output or using smaller weights at the beginning of the training. Working in the linear side of the hyperbolic tangent.

Error functions. The backpropagation learning algorithm depends upon the error function to minimize. In order to get the best model the following error functions were used. Sum-of-squares, cross entropy, absolute value, and Minkowski.

3. Results

During the training of the Multilayer Perceptron initialisation of the weights, the risk of falling in a local minimum and learning rate selection were some of the problems to face. The cross-validation method together with variation in the number of hidden neurons, the weight initialisation range and the learning rate were used to determine the best topology.

The subjects of the study were assigned to two groups 2/3 of the population for the training with whom the model was created and 1/3 for validation or test. ANNs have achieved high values of sensitivity and specificity in the classification of the patients. The best model had 11 inputs, 31 neurons in the hidden layer and one output.

The results for the best model are shown in Table 1.

Table 1. Sensitivity and Specificity for the best model

	Training	Validation
sensitivity	91.58%	88.46%
specificity	79.37%	78.09%

During the neural network training, several modifications of the learning algorithm were used to improve results.

4. Conclusions

A collection of simple clinical markers at hospital admission might, for individual patients, reflect a combination of clinical features that influence prognosis. The use of simple clinical markers readily available at admission of patients with myocardial infarction allows artificial neural networks to give a reliable prediction of risk for in-hospital and 6-month mortality.

We can conclude that ANN are inexpensive, quick and precise tools for assessment of risk for 6-month mortality.

Acknowledgements

Participating Institutions and Investigators for the 'Recursos Empleados en el Síndrome Coronario Agudo y Tiempos de Espera' (RESCATE) study.

G. Sanz, M. Cardona, Hospital Clinic i Provincial de Barcelona; R. Masiá, J. Sala, X. Alvert, Hospital Josep Trueta de Girona; L. Molina, L. Szescielinski, Hospital del Mar de Barcelona; V. Valle, A. Curós, L. Serés, J. Lupon, J. Serra, D. Pereferrer, Hospital Germans Trias i Pujol de Badalona; J. Marrugat, J. Alonso, J. Vila, M. Pavesi, Institut Municipal d'Investigació Mèdica de Barcelona.

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Sepúlveda Sanchis, Jose
 Universidad de Valencia
 (Departamento de Ingeniería Electrónica)
 GPDS Grupo de Procesado Digital de Señales
 Biomedical Engineering PhD Student
 C/ Dr Moliner 50, Burjassot 4100, Valencia, Spain

Jose.Sepulveda-Sanchis@uv.es