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PREDICTIVE MODELS FOR IN-HOSPITAL STROKE MORTALITY

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Abstract: *development of models that can predict potential stroke mortality is important for research purposes, but also to inform families correctly. Using data from Brasov Stroke Registry, we created predictive models for in-hospital acute stroke mortality that include demographic (age, gender), history (arterial hypertension, diabetes mellitus, atrial fibrillation) and clinical information (NIHSS at admittance, type of stroke, arterial territory affected by stroke). Our models have statistical significance and are easy to use, therefore may aid clinicians in their daily decisions, after further validation.*

Key words: *stroke, predictive models, mortality.*

1. Introduction

Stroke is one of the important cause of death and the main cause of disability [1, 2, 3].

Each patient is unique through his personal characteristics and response to treatment. It is useful for neurologists to have instruments that could predict outcome and also may help in individualizing therapy.

A good predictive model should firstly be easy to apply, validated and the parameters included should be largely available (i.e.: including more clinical parameters than investigations that cannot be performed in all patients) [4].

The aim of our study was to develop models that predict the in-hospital mortality of stroke. We focused on demographic, history and clinical data in our models.

2. Material and method

We used data recorded in Brasov Stroke Registry, in which there were enrolled consecutive patients with stroke from Department of Neurology of University Emergency County Hospital Brasov, between August 2011 and March 2012. We recorded demographic data, history, functional status prior to stroke, data regarding admission to hospital, symptomatology of stroke, clinical exam including National Health Institute Stroke Scale (NIHSS) score, vital signs, ECG, neuroimagind – brain CT or MRI scan, treatment during hospitalisation, evolution

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and clinical outcome. Statistical analyses was performed using Medcalc software 12.7.5.0 version for Windows.

We created predictive models for in hospital outcome of stroke by multiple regression analysis. Independent predictive factors were identifyed by Pearson correlation.

3. Results

Amongst the enrolled patients, there were 50 (50, 4%) women and 49 (49, 6%) men, with a mean age of 68, 9±14, 3 years.

The first step in our research was identifying independent predictive factors of outcome.

The NIHSS score at admittance was found to be directly correlated with outcome (p=0.0009, 95% confidence interval=0.14-0.51) as seen in Figure 1. The score is directly correlated with the worse outcome.

Furthermore, we controlled covariates like gender, age, number of stroke risk factors and type of stroke (ischemic or haemorrhagic) and the correlation between NIHSS score at admittance and outcome remains statistically significant (p=0.001). Type of stroke appears to be the most important covariate (correlation coefficient = 0.353 compared to correlation coefficient for age, respectively gender which is 0.34).

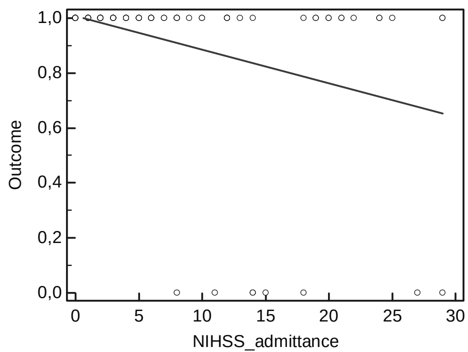

Fig. 1. *Relation between outcome and NIHSS score at admittance; outcome was coded as 1=survival, 0=death.*

We also found a statistically significant correlation between outcome and value of mean blood pressure value at admittance. Linear regression showed that there is a directly proportional relation between the two variables as seen in Fig 2. Therefore, the lower the values of mean blood pressure at onset of stroke, the higher probability of a positive outcome.

There was no association between either values of systolic (p=0,2) or dyastolic (p=0,1) blood pressure and outcome.

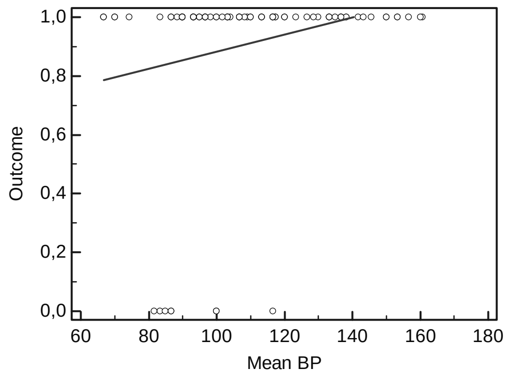

Fig. 2. *Relation between outcome and mean blood pressure at admittance; outcome was coded as 1=survival, 0=death.*

By ROC curves analysis, we compared the sensitivity and specificity of NIHSS score at admittance and mean blood pressure at admittance in predicting stroke outcome. As area under curve was higher for NIHSS score (0,847 vs 0,78), the score is more specific and sensitive in predicting survival from stroke. (Figure 3)

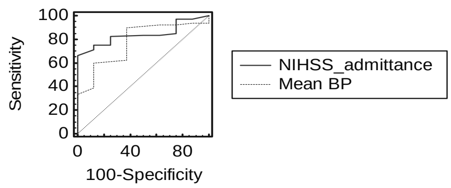

Fig 3 *ROC curve for NIHSS score ant admittance and mean blood pressure at admitance (mean BP).*

Among stroke risk factors, we identifyed statistically significant association between outcome and arterial hypertension (p=0,01), diabetes mellitus (p=0,03) and hypercholesterolemia (p=0,009).

On clinical exam data, quality of gait is the only independent predictor of outcome (p=0,0009).

NIHSS score at discharge (Fig. 4) has been shown to have a leftward shift, with more lower than higher values. It was statistically significant corellated with gender of patients.

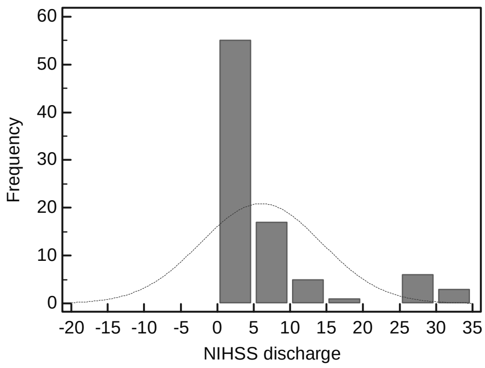

Fig. 4. *Distribution of NIHSS score at discharge (NIHSS discharge).*

Next, we have combined factors that were proven to predict in-hospital outcome of stroke into several models of prediction and analysed their power by multiple regression analysis.

The first model integrates NIHSS score at admittance, age, gender, number of comorbidities and type of stroke. Comorbidities that were counted are stroke risk factors: arterial hypertension, diabetes mellitus, atrial fibrillation, hypercholesterolemia, previous stroke or myocardial infarction.

As seen in Table 1, the model has statistical significance; the variable that enhances the most the predictive value is the number of comorbidities (the greatest increase in R^2 after addition of variable).

First predictive model Table 1

Variables	R^2	p
NIHSS score at admittance	0,1204	0,001
NIHSS score at admittance, age	0,1207	0,004
NIHSS score at admittance, age, gender	0,1211	0,012
NIHSS score at admittance, age, gender, number of comorbidities	0,1368	0,015
NIHSS score at admittance, age, gender, number of comorbidities, type of stroke	0,1475	0,02

The second model comprises NIHSS score at admittance, age, gender and mean blood pressure (BP) at admittance within statistical significance. The variable that increases most the predictive value of model is mean BP at admittance. (Table 2)

Second predictive model Table 2

Variables	R^2	p
NIHSS score at admittance	0,1204	0,001
NIHSS score at admittance, age	0,1207	0,004
NIHSS score at admittance, age, gender	0,1211	0,012
NIHSS score at admittance, age, gender, mean BP at admittance	0,1435	0,014

The next model includes along with NIHSS score at admittance, demographic data like age, two important risk factors for stroke – diabetes mellitus and arterial hypertension. The model has a good statistical significance and the addition of the risk factors for stroke importantly increases the predictive value of the model (Table 3).

Third predictive model Table 3

Variables	R^2	p
NIHSS score at admittance	0,1204	0,001
NIHSS score at admittance, age	0,1207	0,004
NIHSS score at admittance, age, diabetes mellitus	0,1516	0,003
NIHSS score at admittance, age, diabetes mellitus, arterial hypertension	0,1957	0,001

The following model includes clinical exam, paraclinical and history data: NIHSS score at admittance, mean BP, number of comorbidities (arterial hypertension, diabetes mellitus, atrial fibrillation, previous stroke or myocardial infarction), arterial territory and type of stroke. The model has a very good statistical significance. The factors increasing highly predictive value of the model are number of comorbidities and arterial territory involved by stroke. (Table 4)

Fourth predictive model Table 4

Variables	**R^2**	**p**
NIHSS score at admittance	0,1204	0,001
NIHSS score at admittance, mean BP	0,1433	0,002
NIHSS score at admittance, mean BP, no of comorbidities	0,1612	0,002
NIHSS score at admittance, mean BP, number of comorbidities, arterial territory	0,1804	0,003
NIHSS score at admittance, mean BP, number of comorbidities, arterial territory, type of stroke	0,1945	0,004

In the fifth model, we aimed to assess the predictive value of important risk factors for stroke: arterial hypertension, hypercholesterolemia, diabetes mellitus, atrial fibrillation.

Fifth predictive model Table 5

Variables	**R^2**	**p**
Arterial hypertension (HTA)	0,046	0,019
HTA, hypercholesterolemia	0,0800	0,005
HTA, hypercholesterolemia, diabetes mellitus	0,1187	0,002
HTA, hypercholesterolemia, diabetes mellitus, atrial fibrillation	0,1252	0,004

We added them in order of frequency of appearance in history of patients with stroke and obtained a model with important statistical significance. Adding hypercholesterolemia and diabetes mellitus lead to important increases of predictive value of model. (Table 5)

4. Discussions

Apart from allowing a better communication with family who desires to know early what the expected evolution of patient would be, predicting outcome of a case can aid also the clinician in therapeutical decisions. It is important to have simple, rapidly applicable, validated models.

In our models, we have focused on patient characteristics that can be easily identified on admission and did not include laboratory variables as a clinical model can be applied at a shorter time from patient's arrival at hospital.

As in other studies [4, 7, 10] one of the most frequently used predictor of outcome is the NIHSS score. Even after correction for individual characteristics like age, gender, its predictive value remains statistically significant. It appears to have good predictive value both in ischemic and hemorrhagic stroke, as it was showed in studies on larger populations [7]. The NIHSS score correlates well with stroke severity [7].

It may also be useful to assess particular symptoms and signs comprised by NIHSS score that can independently correlate with severity or outcome of stroke [8].

There have been attempts to identify laboratory parameters that can predict mortality in stroke, in particular ischemic stroke. Ghabaee et al. have found an association between values of C reactive protein and stroke mortality; the values of C reactive protein correlate with NIHSS scores at admittance [2].

Certain scoring systems involve repeated measures of some parameters which is time costly and can lead to difficulties in applying them. Therefore a team of researchers from Cambridge validated an 8 point scoring system based on patient characteristics that have been observed as varying in a dependent trend with mortality after stroke. This score involves demographic factors like age and gender, clinical data like stroke subtype, but also functional status of patient before the acute event [6].

Other group from United Kingdom found that taking into account age of patient, stroke subtype, Rankin status before stroke, Oxfordshire classification of stroke, there can be obtained a score useful to predict mortality in the first week [5].

A score developed by a team from Essen, Germany takes into account age, NIHSS score, certain specific factors like the function of right arm, medical history (previous stroke, diabetes), complications – both neurological or non-neurological like fever; this model has good predictive value both for functional outcome and mortality [9].

Similarly, we have combined in most of our models NIHSS score with factors that can worsen the evolution of stroke or show that the organism of the patient does not have full resources to recover. These include classical risk factors for stroke (high blood pressure, diabetes, atrial fibrillation, dyslipidemia).

There have been proposed models to predict mortality and functional outcome that take into account volume of ischemic tissue measured by MR DWI [1, 3].

The weakness of our study consists in the relatively small number of cases included, but the project is to be further developed, by supplementary addition of other predictive factors both clinical and imaging or laboratory tests.

5. Conclusions

Scores that predict stroke mortality can be developed with aid of clinical data and characteristics of patient – demographic data, medical history. They must first be well validated so that physician can obtain trustworthy information by applying them in daily practice. The models we designed can be a start for an easy to apply scoring system for stroke in hospital mortality.

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