AN ESTIMATION OF SURVIVAL TIME AFTER BRAIN STROKE USING HEART RATE TURBULENCE AND HEART RATE VARIALIBITY PARAMETERS AS PREDICTORS

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Abstract: The papers presents some considerations concerning non-invasive estimation of survival time of patients after brain stroke. It is a sort of stereotype to think that patients suffering from the both early and late stages after brain stroke are in fact at great risk concerning sudden brain death and it is extremely hard to find out the most suitable therapy leading them back to normal life. Fortunately, slowly this last sentence become more and more less valid. Recent achievements in this area allow to conclude that e.g. extensive trombolitic therapy offers quite promising follow up for patients after brain stroke and therefore the survival time is permanently increasing. However, still open problem is how to estimate that time using both risky direct methods and risk-free indirect methods based upon application of sophisticates signal processing tools. A partial answer for this questions is presented in this paper.

Introduction

The paper presents in brief a new approach to the estimation of survival time in case of patients suffering from the brain stroke. The novel aspect of the presented approach is in application of the state of the art measurement methods and techniques such as analysis of heart rate variability (HRV) and heart rate turbulence (HRT). Such data have been obtained through the ECG signal recording lasting 24 hours using Holter method i.e. with the help of solid state recorder.

Several parameters from both time and frequency domain analysis of heart rate variability (HRV) signal have been taken into account for estimation of survival time. Also the two characteristics parameters such as turbulence onset (TO) and turbulence slope (TS) from the area of HRT analysis have been taken into considerations.

Materials and Methods

There have been 21 patients under examination. Each patient had mentioned above Holter method ECG signal registration during or around first day after brain stroke, tenth day and finally sixty days. For 5 patients the last registration has not been performed due to the death. Turbulence onset can be defined as the percentage difference between the heart rate immediately following PVC and the heart rate immediately preceding PVC. It has been calculated using the following equation :

$$TO = \frac{(NN_1 + NN_2) - (NN_{-2} + NN_{-1})}{NN_{-2} + NN_{-1}} * 100 \qquad (1)$$

with RR_{-2} and RR_{-1} being the first two normal intervals preceding the PVC and RR_1 and RR_2 the first two normal intervals following the PVC. Initially, TO has been determined for each individual PVC, followed by the determination of the average value of all individual measurements. Positive values for TO indicate deceleration, negative values indicate acceleration of the sinus rhythm. The Turbulence Slope (TS) corresponds to the steepest slope of the linear regression line for each sequence of five consecutive normal intervals in the local tachogram. The Turbulence Slope calculations are based on the averaged tachogram and expressed in ms per RR interval.

Results

As a first approach for survival time estimation all the mentioned parameters such mean HR, SDNN,

$$SDNN = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(NN_i)^2 - \left(\frac{1}{n}\sum_{i=1}^{n} NN_i\right)^2} \qquad (2)$$

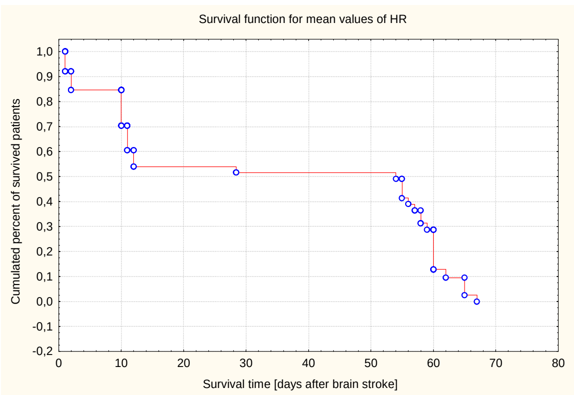

Figure 1: Survival time estimation for mean HR

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SDANN (Standard Deviation of Averaged NN Intervals), p50NN defined as the relative numbers of NN intervals differing by more than 50 ms from the immediately preceding NN interval, in time domain as well as the area under PSD (Power Spectral Density) curve in LF (low frequency (0.04-0.09Hz)), HF (high frequency(0.09-0.15Hz)), VLF (very low frequency i.e. below 0.04Hz) ranges in frequency domain have been taken into consideration.

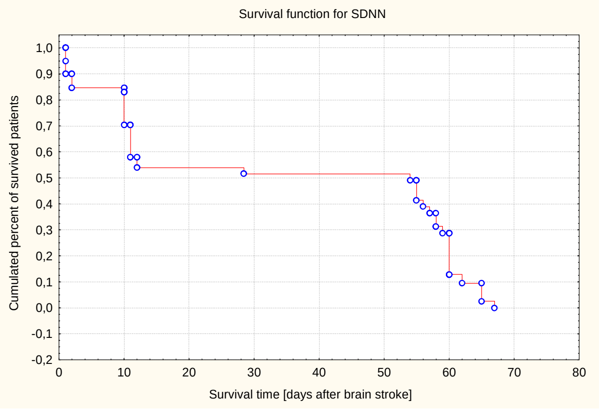

Figure 2: Survival time estimation for SDNN

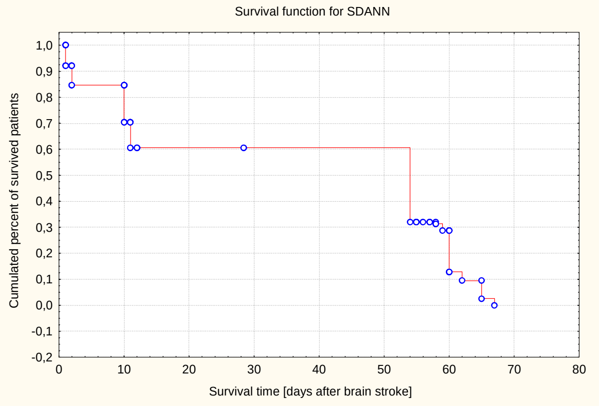

Figure 3: Survival time estimation for SDANN

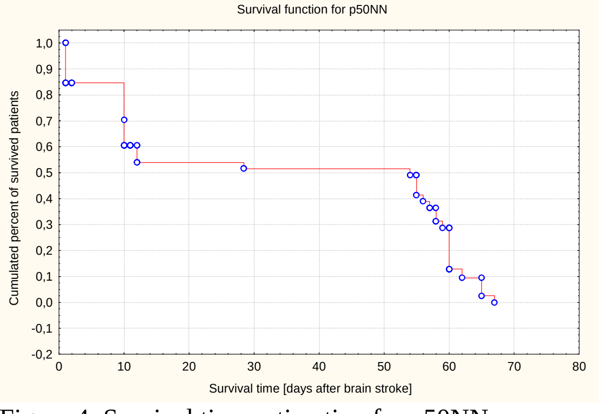

Figure 4: Survival time estimation for p50NN

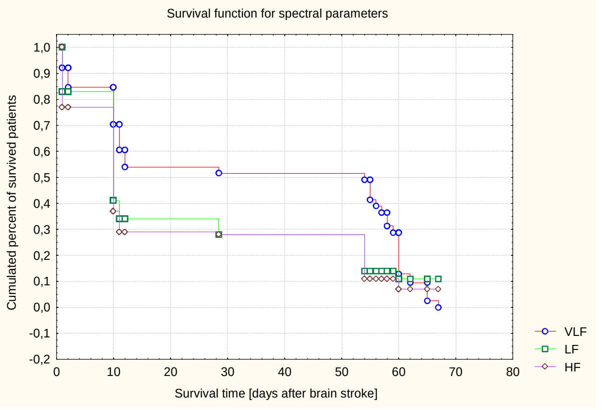

Figure 5: Survival time estimation for spectral parameters (LF, HF and VLF)

In term of HRT parameters the analysis has not been so easy. The result coming out from that fact should be considered with the information concerning some specificity of cardiovascular disease as in some cases the observation of PVC has been impossible following the estimation of both TO and TS impossible also.

Conclusions

There are several important conclusions coming out from the precise diagnosis point of view, which has been created available applying presented approach.

The most important conclusion is that presented approach is totally non-invasive and therefore stress less for patient after brain stroke.

The analysis goes far more deeper and takes later separate analysis for selected case like gender, age in the defined ranges, groups coming from the neurologist estimation using both Scandinavian and Repty brain stroke scales.

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