ANALYSIS OF THE HEART RATE VARIABILITY BEFORE AND AFTER ASPHYXIA

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Abstract: Over the last two decades there has been a widespread interest in the study of variations in the beat-to-beat timing of the heart, known as heart rate variability (HRV). The studies of heart rate variability have allowed access to useful information about disturbances in autonomic regulation, which are a promising marker to quantify autonomic activity. Heart rate variability has become the conventionally accepted term to describe variations of both instantaneous heart rate and RR intervals (the RR interval is the time interval between two consecutive R-points of the QRS complex) (D. Bajic *et al.*, 2006). The objective of this paper is the analysis and comparison of the HRV before and after asphyxia using data from previous studies where 24 adult Wistar rats were anesthetised and subjected to controlled asphyxia for specified durations (Boardman *et al* 2002). Preliminary results of our work show a depression of this parameter after long periods of asphyxia, indicating that HRV might be a good marker for assessing injury to the autonomic nervous system due to asphyxia.

1 INTRODUCTION

Cardiac activation is an electrical propagation that spreads over the structure of the heart in a coordinated pattern leading to an effective systole. This results in a measurable change in potential difference on the surface of the body of the subject. The resultant amplified and filtered electrical signal is the electrocardiogram and it is widely used to measure the heart rate and heart rate variability (Azuaje *et al.*, 2007).

The base line variability of the heart rate time series is determined by many factors. However, not only does the mean beat to beat interval (the heart rate) change on many scales, but the variance of this sequence of each heartbeat interval does so too. On the shortest scale, the time between each heartbeat is irregular. These short term oscillations reflect changes in the relative balance between the sympathetic and parasympathetic branches of the autonomic nervous system (ANS), the sympathovagal balance. This heart rate irregularity is a well studied effect known as heart rate variability (HRV) (Azuaje *et al.*, 2007). A reduction of HRV has been reported accompanying many cardiac and cerebral conditions including foetal brain stem injury; severe neonatal respiratory distress syndrome is accompanied by a reduction in low-frequency heart rate variability, if the respiratory distress improves heart rate variability increases (Buerk *et al.*, 1997).

The purpose of the current study is to assess the heart rate variability before and after asphyxia periods and determine its correlation with the severity of the insult. To do this, data arising from several experiments where 24 adult Wistar rats were anaesthetised and subjected to controlled asphyxia for specified durations were used (Boardman *et al.*, 2002).

2 METHODS

2.1 Statistical Method

The application of statistics to medical data is often used to design experiments and clinical studies, to summarize, explore, analyse, and present data, to draw inferences from data by estimation or hypothesis testing, to evaluate diagnostic procedures, and to assist clinical decision making (Azuaje *et al.*, 2007). Since changes in the ECG are

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quasi-periodic, on beat to beat basis, the frequency can be quantified in statistical terms (Azuaje *et al.*, 2007)Simple linear time domain statistics such as standard deviation (SD) and root mean square of the successive R-R intervals have been often employed to analyse HRV fluctuations providing insights into the autonomic cardiac regulation (Bezerianos *et al.*, 2004).

In this study the assessment of the HRV is carried out / determined by the standard deviation of normal RR intervals (figure 1).

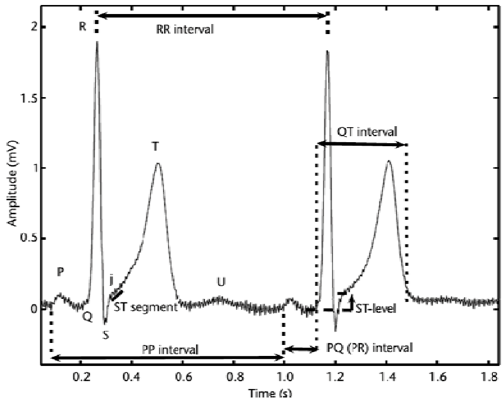

Figure 1: Points and Intervals in the ECG.

Often the RR interval will oscillate periodically, shortening with inspiration (and lengthening with expiration). This is known as 'respiratory sinus arrhythmia' and is mediated by the Bainbridge reflex.

2.2 Geometrical Method

Time-Domain analysis of heart rate variability is a statistical approach describing the magnitude of the variability around a mean, but it does not provide information about the characteristics of these variations (Acanfora *et al.*, 1998). Beat to beat variation can also be displayed by plotting each RR interval against that of the preceding RR interval, and allows the identification of beat to beat cycles and patterns in data that are difficult or maybe not observable by other methods of analysis.

This Poincaré plot analysis is a quantitative visual technique taken from nonlinear dynamics, whereby the shape of the plot is categorized into functional classes (Smith *et al.*, 2003), (Brennah et al., 2001). Poincaré plots provide summary information as well as detailed beat to beat information on the RR variability (Buerk *et al.*, 1997).

3 RESULTS

Using the SDNN (figure 2) for the RR intervals we take the absolute value of each deviation before the summation otherwise the positive and negative terms would average to zero. The important parameter is not the deviation from the mean, but the power represented by the deviation from the mean. (Smith *et al.*, 2003)

$$\sigma^2 = \frac{1}{N-1}\sum_{i=0}^{N-1}(x_i-\mu)^2$$

$$\sigma = \sqrt{\frac{(x_0-\mu)^2+(x_1-\mu)^2+(x_2-\mu)^2+\ldots+(x_{N-1}-\mu)^2}{N-1}}$$

Figure 2: Calculation of the standard deviation of the signal.

We apply this method to the first 5 minutes and the last 3.5 minutes for each group, to measure the behaviour of HRV before the asphyxia is present and after the insult. The results are summarised in table 1.

Table 1: Comparison before / after asphyxia.

Group	Before	After
One Minute	3.47 ms	1.87 ms
Three Minute	0.42 ms	0.14 ms
Five Minute	0.68 ms	0.32 ms
Seven Minute	0.34 ms	0.12 ms

Another comparison of the HRV was performed using Poincaré plots for each group, plotting the RR intervals against the immediate value (figures 3, 4, 5 and 6).

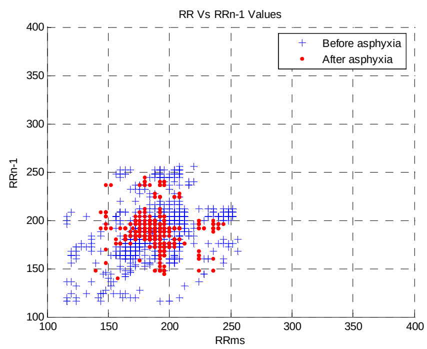

Figure 3: Comparison before/after asphyxia for one minute.

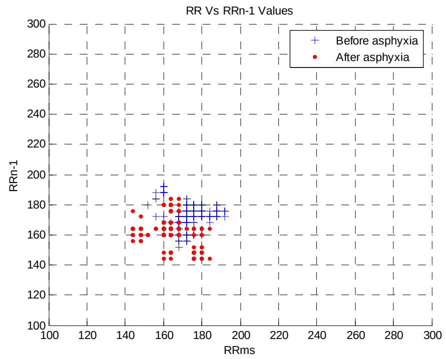

Figure 4: Comparison before/after asphyxia for three minutes.

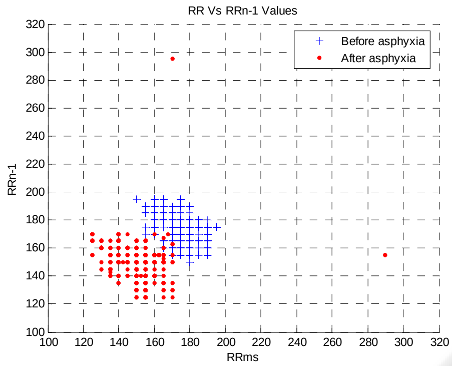

Figure 5: Comparison before/after asphyxia for five minutes.

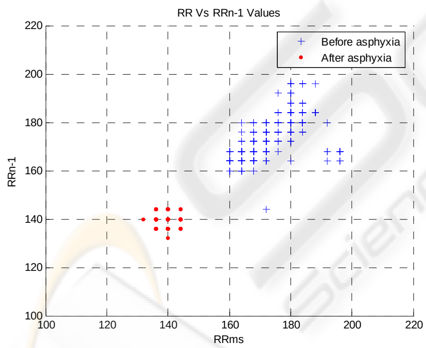

Figure 6: Comparison before/after asphyxia for seven minutes.

4 CONCLUSIONS

The results showed that for both methods the heart rate variability had a marked increase during the asphyxia. After the asphyxia occurs the HRV had a marked decrease for longer periods of asphyxia, while for shortest periods the drop of the HRV was not so severe (figure 7).

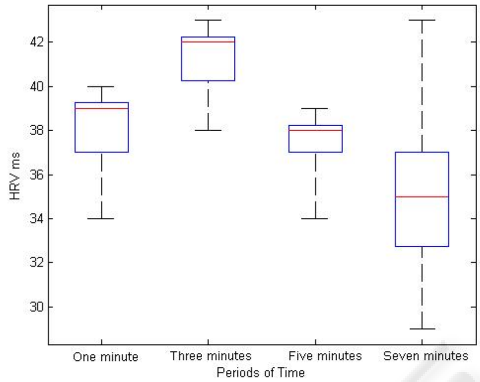

Figure 7: Decrease of The HRV after longer periods of asphyxia.

We observed that the relation between the increase and decrease of the heart rate variability before and after asphyxia could be used as an indicator of the severity of the injury to the autonomic nervous system; HRV might then be a promising marker to estimate the severity of the asphyxia. In the future it will be interesting to investigate longer periods of asphyxia to see if this observation is confirmed.

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