Heart of Darkness: Heart Rate Variability on Patients with Risk of Suicide

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Heart Rate Variability on Patients with Risk of Suicide

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Abstract— **Heart Rate Variability (HRV) is an emerging research field in the study of diverse pathologies, as long as it allows considering another measurement for detecting possible aggravations. The aim of this work is to study the applicability of the analysis of HRV in order to establish if a person is at risk of suffering from suicidal ideation.**

This work includes the development and testing of a heart rate acquisition and automatic analysis system, with friendly software for clinicians, customized to the necessities of an emergency unit. Furthermore, it includes the analysis of the obtained data with the purpose of assessing possible correlations between HRV parameters and personality impulsive traits.

20 patients and 10 normal cases were selected to develop this pilot study. Results show significant statistical difference ($p<0.05$) among patients and normal cases for pNN50, IRRR, MADRR, total HRV power, Approximate Entropy and Fractal Dimension.

Heart rate variability; suicidal ideation; RHRV package

I. INTRODUCTION

Heart rate variability (HRV) measures the variations of the sequence of intervals between heartbeats, being a reliable quantitative measurement of the activity of the autonomous nervous system. An increased HRV reflects the existence of a healthy autonomous nervous system capable of responding to environment changes. Conversely, a decreased HRV is a marker of autonomous inflexibility and disease. In particular, a low HRV is a risk factor of heart disease, and it could explain the relationship between depression and heart disease [1]. A decrease of the HRV has been repeatedly described in depressive patients [2].

The study of HRV in relation to suicide risk is relatively recent, and there are evidences that justify its usefulness in order to valuate impulsiveness in patients of risk.

According to statistics of Galician Government, deaths due to suicides increased last year in Ourense (Galicia, Spain), up to 45 cases, which implies a rate of 13,5 deaths by 100.000 inhabitants, higher than the Spanish national mean of 6,99. To illustrate this, it can be pointed out that the deaths due to suicide exceeded the deaths due to traffic accidents [3].

A suitable strategy for prevention is the identification of higher suicidal risk cases after a suicide attempt; for that reason epidemiological and clinical (psychiatric and psychological) profiles are analysed in Emergency Units. Nevertheless, these instruments along with exhaustive clinical interview may present several problems, such as long required time spans for accurate patient evaluation, big inter-observer variability, and lack of trustworthy answers by the patient and his/her relatives.

Therefore, it would be desirable to have biological markers of impulsiveness (endophenotypes) alerting to the clinicians of the existence of these personality traits in the patients, and the increase in risk they involve.

Different studies point out the relationship between HRV and suicidal ideation. For example, Rottenberg [4] suggests the possibility that a low parasympathetic tone is related to certain depressive symptoms (like suicidal ideation), and it is not related to depressive syndrome at all. On the other hand, Booij et al. [5] showed that HRV reduction is related to an increase of the impulsivity of patients with a previous record of suicidal ideation.

Recently, Chang et al. [6] confirmed these findings, showing that patients with fully remitted major depressive disorder presented no dysregulation of the HRV as compared with controls, except for the subgroup with a record of suicidal ideation. The reduction of parasympathetic activity as compared to controls was described also in parasuicidal adolescents [7].

Spectral study of HRV can provide a quantitative analysis as well as an evaluation of the neurovegetative nervous system: the sympathetic equilibrium can be evaluated employing low frequency components, while parasympathetic tone can be estimated employing high frequency components.

Available commercial software for HRV analysis is restricted to a limited number of parameters, and usually it does not allow specific functionality needed by the specialists. These limitations forces investigators to develop their own software. To facilitate the work of these researchers we have developed a package called RHRV [8], an easy-to-use tool for time, spectral and nonlinear analyses of heart rate signals.

This research work intends to determine the applicability of this package to analyze HRV along with personality tests, in order to detect suicidal ideation in a clinic environment.

The paper is structured as follows. In Section II we describe our methods. In Section III our results are presented. Finally, a discussion section is included in which we summarize the main contributions of this study and describe further work.

II. METHODS

A. Patients

In this study, volunteer patients older than 18 years and younger than 65 were included. They were selected among:

- Patients admitted in the emergency observation room, passing more than 12 hours after the suicidal attempt, going to be discharged and with psychiatric evaluation.
- Patients admitted in the Psychiatry Unit due to a self-harm attempt by any mechanism or suicidal ideation, independently of their base psychiatric pathology.

Control normal, healthy subjects were also selected among volunteers of our University, (both students and teachers), without psychiatric pathology.

The informed consent was collected after the clinician informs patients about their voluntary collaboration in this study.

B. Materials

The heart rate was measured by means of a noninvasive device: sports watch Polar RS800CX (heart rate monitor) with chest strap (heart rate sensor) (Fig.1). The IrDA USB Adapter provides the link between watch and computer by enabling a two-way infrared data communication, allowing heart rate files to be transferred from watch to computer.

The heart rate registration was done in repose state (supine position) and for duration of about 15 minutes.

For HRV analysis the RHRV package was used. This package is described elsewhere [8]. Among many other features, RHRV includes HRV analysis both in time and frequency domains, as well as nonlinearity indices. Furthermore, it allows the inclusion of episodes (intervals of physiologic interest) to study HRV inside/outside these episodes. Time evolution of different parameters can be also obtained. RHRV has been used to analyze HRV in chronic obstructive pulmonary disease patients [9] or to analyze nocturnal evolution of HRV in sleep apnea [10].

Figure 1. Sports watch Polar RS800CX, chest strap and IrDA USB Adapter.

The following parameters were calculated in this work:

- Time domain analysis: standard deviation of intervals between consecutive heart beats (SDNN), proportion of interval differences of successive intervals greater than 50 ms (pNN50), root mean square of successive differences (r-MSDD), difference between third and first quartile of the intervals distribution (IRRR), median of the absolute differences of the RR intervals (MADRR), is the triangular interpolation of intervals histogram (TINN), and integral of the density distribution divided by the maximum of the density distribution (HRVi).
- Frequency domain analysis: power in low frequency band (LF), power in high frequency band (HF), ratio for the LF and the HF bands (LF/HF), and total power (HRV).
- Non-linear analysis: Approximate Entropy (ApEn), and Fractal Dimension (FracDim).

C. Clinical and sociodemographic variables

Furthermore, sociodemographic and forensic data were collected (age, gender, marital status, employment status, previous psychiatric pathology, pharmacologic treatments, previous attempts of suicide, family history of suicide, alcohol or drugs abuse, mechanism of suicide and its lethal nature, intentionality, motivation, and cause), and the following psychological tests were made: revised version of Cloninger test TCI-R-67 [11], Beck Hopelessness Scale [12], and Hamilton Depression Scale [13]. The main features of these tests are:

- Cloninger Test: version TCI-R-67 of the Cloninger personality inventory was used. This test consists of 67 questions about seven dimensions: Novelty Seeking, Harm Avoidance, Reward Dependence, Persistence, Self-Directedness, Cooperativeness, and Self-Transcendence. This study is mainly centered in the first two dimensions; we are interested in high levels of Novelty Seeking and low levels of Harm Avoidance.
- Beck Hopelessness Scale: it is composed by 20 questions and its final score indicates the level of risk of suicide: 0-8 meaning low risk (0-3 null or minimum risk and 4-8 slight risk), while 9-20 indicating elevated risk (9-14 moderated and 15-20 high risk).
- Hamilton Depression Scale: this scale contains 17 items, the final score indicating the degree of depression of the patient: 0-7 normal, 8-13 slight or minor, 14-18 moderate, 19-22 severe, and >23 very severe depression.

III. RESULTS

The first remarkable result is the implementation of a protocol of heart rate acquisition as an activity in routine patient examination. The clinicians were satisfied with the Polar RS800CX, and it did not pose any problem for them. Twenty subjects were selected during a three months period among patients admitted in the emergency observation room,

complying with the conditions expressed in Section II.A. Ten control subjects were selected among volunteers of our University (students and teachers) following the same protocol of acquisition.

First of all, a preliminary study was conducted with the intention of setting up the experimental procedure. We developed scripts to automate data acquisition, we checked the quality of heart rate records and we selected the diagnostic groups.

After this exploratory period, several studies were designed, paying special attention to impulsivity, reflected in variables as Novelty Seeking and Harm Avoidance (Cloninger Test), high risk of suicide (Beck Hopelessness Scale), or non toxic mechanism of suicide. The designed studies are shown in Table I.

TABLE I. PERFORMED STUDIES

Study	Group 1	Number of cases	Group 2	Number of cases
1	Non toxic mechanism of suicide	9	Toxic mechanism of suicide	10
2	Low-Medium Harm Avoidance	11	High Harm Avoidance	4
3	High Novelty Seeking	11	Low-Medium Novelty Seeking	4
4	Depressive patients according to Hamilton Depression Scale	12	Non depressive patients according to Hamilton Depression Scale	7
5	Patients with risk of suicide according to Beck	17	Patients with no risk of suicide according to Beck	2
6	Patients with elevated risk of suicide according to Beck	13	Patients with slight risk of suicide according to Beck	4
7	Patients with Low-Medium Harm Avoidance & High Novelty Seeking simultaneously	7	Patients without Low-Medium Harm Avoidance & High Novelty Seeking simultaneously	8

For the sake of simplicity, only remarkable results of studies described below are shown in Table II.

TABLE II. SOME INTERESTING RESULTS

Study	Variable	Group 1		Group 2		p
		Mean	*s.d.*	*Mean*	*s.d.*	
3	ApEn	1.00	0.25	1.30	0.03	0.003
	FracDim	3.34	0.45	3.90	0.34	0.035
2	HF	49.63	42.06	71.31	89.62	0.67
7	HF	47.97	34.29	59.22	70.26	0.70

No statistical significant differences between the variables of the two groups were found, except for the non-linear analysis parameters Approximate Entropy and Fractal Dimension of study number 3, indicating a decrease of variability for more impulsive patient. Although interesting decreases between powers in the HF bands of more impulsive patients were observed (studies number 2 and 7), these differences are not significant, possibly due to the small sample size.

New analysis were made comparing Group 1 of studies number 1, 2, 3, and 7, versus healthy group. We have also compared all patients versus healthy group (shown in Table III). In all these studies we obtained significant differences for several time analysis parameters (MADRR, IRRR, pNN50), for the non-linear analysis parameters (ApEn, FracDim), and for total power (HRV).

TABLE III. PATIENTS VERSUS HEALTHY GROUP

Variable	Group 1		Group 2		p
	Mean	*s.d.*	*Mean*	*s.d.*	
SDNN	57.87	28.02	70.76	34.82	0.33
pNN50	8.09	10.21	23.31	20.19	0.05
r-MSSD	28.02	15.34	47.69	30.97	0.08
IRRR	26.95	17.39	58.50	35.93	0.02
MADRR	13.61	8.76	29.70	18.63	0.03
TINN	105.62	57.91	110.93	37.01	0.77
HRVi	13.52	7.41	14.20	4.74	0.77
LF	362.52	472.50	925.32	1074.58	0.14
HF	51.61	49.49	115.51	135.87	0.18
LFHF	12.69	6.73	16.53	14.36	0.44
HRV	100652.30	29450.33	144413.00	43605.92	0.01
ApEn	1.04	0.26	1.35	0.14	0.0002
FracDim	3.38	0.58	3.95	0.38	0.004

Some differences, although still not statistical significant, are considerable (see Table III). For example, the value for HF band for patients is 51.61 (s.d. 49.49), and for normal cases is 115.51 (s.d. 135.87), but p value is 0.18. Figure 2 illustrates this showing HF values for all cases. A decrease of HF power in patients group with respect to healthy group is observed. The inclusion of a greater number of cases could help to elucidate the significance of these differences or similarities.

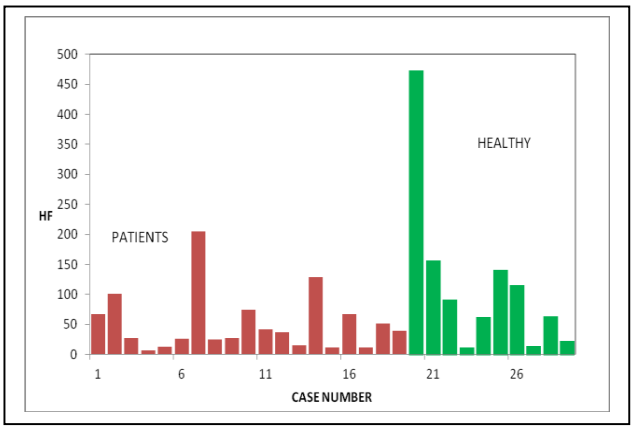

Figure 2. HF values for all cases.

IV. DISCUSSION

This work shows the feasibility of using HRV analysis as a tool for the diagnosis of suicidal ideation. The HRV analysis is not included as a routine in clinical environment; nevertheless it seems a useful instrument that can be complementary to other tools such as personality tests and patients' records.

Our results suggest possible differences between groups, although these differences were not found significant, possibly due to the small sample size. The value of power in the HF band for patients shows a drop versus healthy group, as Rottenberg indicated for suicides [4]. Chang [6] and Crowell [7] obtained similar results, concluding that HF reflects parasympathetic tone and it is reduced in suicidal cases. The differences in total power of RHV are significant in those studies where impulsivity of patients is evaluated (number 1, 2, 3, and 7) versus normal cases, as Booij investigated in [5].

The results obtained are far from being definitive, mainly because of the small number of cases. We are working to increase the number of cases and to improve the analysis of the heart rate signals.

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