DOI Number: 10.5958/2320-608X.2019.00052.0

HRV During One Minute Controlled Deep Breathing for Evaluation of Sympatho Vagal Imbalance in Type 1 Diabetes Mellitus Patients

M.Janet Sugantha[1], M.Rathnavelkumaran[2], K.Muralikrishnan[3]

[1]*Associate Professor, Department of Physiology, K.A.P.V. Govt. Medical College, Tiruchirapalli,* [2]*Assistant Professor, Department of Physiology, Chengalpet Medical College,* [3]*Professor, Department of Physiology, Kilpauk Medical College, Chennai*

Abstract

Introduction: The Autonomic nervous system is the principle way by which the heart rate can be controlled effectively. The integrity of the autonomic control of the cardiovascular system in diabetic patients can be studied by observing the heart rate variability (HRV)

Materials and Method: 30 type 1 diabetic patients attending the Diabetology clinic of Stanley Medical College, Chennai and 30 age matched controls were enrolled. Heart rate variability analysis during one minute controlled deep breathing was performed on all the subjects and the results obtained were compared between the groups

Results: HRV analysis in type 1 diabetes mellitus patients show

Significant reduction in SDNN, RMSSD, NN50 and pNN50

Significant reduction of mean RR, HF and HF nu, compared to that of controls

Conclusion: HRV during one minute controlled deep breathing is a simple non invasive test to detect cardiac autonomic neuropathy. Hence HRV db should be recommended as a screening test for diabetes mellitus patients.

Keywords: *Type 1 diabetes mellitus, Autonomic neuropathy, heart rate variability, HRV with deep breathing*

Introduction

The heart and vascular system are innervated by both parasympathetic and sympathetic nerves. The predominant supply of vagus is to the pace maker and conducting system and the sympathetic supply is more for cardiac muscle and vascular system. So the changes in the heart rate are predominantly modulated by the vagus and the contractility of cardiac muscle is brought about by sympathetic pathway. Although some local factors, such as temperature, hormone changes and stretch of tissues can change the heart rate, the Autonomic nervous system is the principle way by which the heart rate can be controlled effectively. The integrity of the autonomic control of the cardiovascular system in diabetic patients can be studied by observing the heart rate variability (HRV)

The first report linking HRV to respiration has been credited to Karl Ludwig, who in 1847 noted that heart rate increased with inspiration and decreased with expiration [1,2]

Clinical interest in HRV was sparked by the 1973 report of Wheeler and Watkins, who first drew attention

Corresponding author:
Dr. M. Janet Sugantha,
Associate Professor, Department of Physiology,
K.A.P.V.Govt. Medical College, Tiruchirapalli
Email id: janet.sugantha@gmail.com

to cardiac vagal innervations as the mediator of HRV and its potential value as a clinical test of cardiovagal function [3]

These investigators studied HRV with deep breathing (HRVdb) in normal subjects and diabetic patients , some with and some without evidence of autonomic neuropathy. They noted that HRV db was reduced or abolished in diabetic subjects with autonomic neuropathy and concluded that HRV db was a clinically useful test for autonomic neuropathy in diabetic patients.

Analysis of HRV can be studied in the frequency domain by using Fourier transformation and converting heart rate to a power spectrum [4] The peak power at the highest frequencies (> 0.15Hz) reflects respiratory sinus arrhythmia, while the lower frequencies reflect both sympathetic and parasympathetic influences. Marked reduction in the power spectrum was noted in patients with diabetic autonomic neuropathy[5]

Aim of the Study: To study the Cardiovascular Autonomic function in Type 1 Diabetics by doing Heart Rate Variability (HRV) analysis during one minute controlled deep breathing

Materials and Method

The study was conducted in the Research Lab of the Department of Physiology, Stanley Medical College, Chennai.

Cases:

Inclusion Criteria

Type 1 Diabetes mellitus patients (based on WHO criteria) attending Diabetology out-patient department

Age: 10 to 40 years, both gender

Type 1 diabetic patients on Insulin treatment and with fairly good glycemic control

Type 1 DM patients with duration of disease > 2 years

Exclusion Criteria

Smokers

Alcoholics

Hypertension, Coronary artery disease, Renal disorders, Thyroid disorders

Patients with history of autonomic dysfunction

Controls

30 age and gender matched healthy subjects attending the Master health check up programme, Stanley Medical College.

Study Design : Cross-sectional study.

The **study protocol was approved by the Ethical committee of Stanley Medical College.**

The detailed procedure and purpose of the study was explained in the regional language, and then an **informed and written consent** was obtained from the subjects if they were 16 years of age or over and from their parents if they were younger than 16 years.

Equipment and Methodology Of HRV

ECG was acquired using RMS Polyrite D hardware 2.2 (India), and instantaneous heart rate at RR intervals were plotted using RMS 2.5.2 software on a Microsoft window based PC. The RMS Polyrite 2.5.2 helps to save multiple records and provided with additional filter settings, calculation tools, automated analysis and auto report generation. Respiratory movements were recorded using respiratory belt.

The recordings were done between 10 a.m. and 12 noon to avoid circadian variations. Height and weight were taken. Blood Pressure was recorded using sphygmomanometer. The lab environment was quiet, the temperature was maintained between 25 to 28°C and the lighting subdued. Subjects were asked to empty their bladder before the test. The test did not involve any intravascular instrumentation or administration of any drugs at any stage.

The subjects were made to sit in the lab for 10 minutes to get accustomed to the new environment. The subjects were clearly instructed not to take coffee, tea or cool drinks 1½ hours before test.

1. Electrodes were fixed in the following position after cleaning with spirit to record the ECG

Electrode	Position
Exploring Electrode	Left shoulder/forearm
Exploring Electrode	Right shoulder/forearm
Reference Electrode	Right leg

2. Respiratory belt was tied around the chest at the level of the nipple to record respiratory movement

3. The electrodes and the respiratory belt were connected to RMS Polyrite D equipment. Task force guidelines [6] were followed

HRV during one minute controlled deep breathing

The subject was asked to lie down comfortably in the supine position. He was then instructed to breathe slowly and deeply at the rate of 6 breaths per minute in such a way that he takes 5 seconds for inspiration and 5 seconds for expiration. The entire procedure was monitored on the screen. Deep breathing will produce maximum Respiratory Sinus Arrhythmia.

Results

Statistical Package for Social Sciences (SPSS) software 11.5 version was used for statistical analysis.

The Student independent unpaired 't' test was used to compare cases and controls.

$p < 0.05$* is taken as significant ;

$p < 0.01$** is taken as highly significant

Table 1: Anthropometric measurements of subjects

(Age, Height, Weight & BMI expressed as Mean ± SD)

	CASES	CONTROLS	't'value	p value
n	30	30	-	-
Males:Females	18:12	18:12	-	-
Age in years	23.06 ± 6.06	22.86 ± 5.92	0.12	0.89
Height in cm.	155.96 ± 9.25	156.80 ± 9.57	-0.34	0.73
Weight in kg.	53.83 ± 7.86	54.23 ± 7.88	-0.19	0.84
B.M.I. kg/m2	22.07 ± 2.31	21.98 ± 2.17	0.15	0.87

Table 2: Heart rate & blood pressure measurements

	GROUP (n=30)	MEAN	STANDARD DEVIATION	Student independent 't' test
Resting Heart rate In bpm	Cases	87.3	8.4	t = 4.05 **p < 0.01****
	Controls	76.4	12.01	
Systolic B.P. (mm.Hg.)	Cases	120.60	5.61	t=1.597 p=0.116
	Controls	118.00	6.92	
Diastolic B.P. (mm.Hg).	Cases	79.40	4.64	t=0.858 p=0.395
	Controls	78.33	4.98	

Table 3: Comparison of blood sugar level

	GROUP (n=30)	MEAN	STANDARD DEVIATION	Student independent 't' test
Fasting mg%	Cases	124.06	18.20	t= 12.22 **p< 0.01****
	Controls	82.33	4.29	
Post prandial mg%	Cases	158.34	31.22	t=8.77 **p<0.01****
	Controls	107.93	3.94	

Table 4: Frequency Domain Measures During One Minute Deep Breathing

Frequency Domain Measures	Cases (n=30)		Controls (n=30)		Student independent 't' test
	Mean	**SD**	**Mean**	**SD**	
Mean RR in sec.	0.72	0.07	0.83	0.11	t= -4.091 **p<0.01****
HF in ms²	0.82	1.01	1.91	1.72	t= - 3.008 **p<0.01****
HF in n.u.	18.89	9.10	28.40	11.89	t= - 3.47 **p<0.01****

Table 5: Time Domain Measures During One Minute Deep Breathing

Time Domain Measures	Cases (n=30)		Controls (n=30)		Student independent 't' test
	Mean	SD	Mean	SD	
SDNN ms	50.33	19.17	88.76	20.56	t= - 7.48 **p<0.01****
RMSSD ms	56.62	32.12	98.76	24.18	t= - 5.74 **p<0.01****
NN50	8.73	7.82	28.16	11.56	t= - 7.62 **p<0.01****
pNN50%	14.25	14.43	38.72	15.76	t= - 6.27 **p< 0.01****

Discussion

HRV with deep breathing is the simplest and most widely performed measure of autonomic control of the heart. This test produces a sensitive, specific and reproducible indirect measure of vagal cardiac function.

Fareedabanu et al [7] found a statistically significant decrease in mean minimal heart rate and one minute HRV during deep breathing among type 2 diabetic patients on comparison with that of healthy controls

Respiratory sinus arrhythmia (RSA) is a change of heart rate generated by a combination of respiration-induced biochemical changes, changes in intrathoracic pressure, and central vagal stimulation[8]. Respiration has a significant effect on the Heart rate oscillations and parasympathetic activity is very closely related to respiratory sinus rhythm. Frequency of RSA component falls in High Frequency range of HRV (0.15-0.4 Hz) for more than 6 breaths/min. On one minute controlled deep breathing at 6 breaths/min, with inspiration and expiration each lasting for 5 secs. the mean RR was significantly reduced in diabetic patients(p<0.01**).

In the frequency domain measures the HF in absolute power and HF in normalized units was significantly reduced in diabetics (p<0.01**) which might have been due to vagal neuropathy [18,25]. HRV during timed deep breathing is a major index of HR variation in the time domain because it has been shown to be one of the most reliable and reproducible markers of parasympathetic modulation of cardiac function [(11).] All the time domain variables were significantly reduced in diabetics (p< 0.01**). Reduced HRV during deep breathing in type 1 diabetics clearly indicates that cardiac vagal effects are diminished in this condition. This may possibly be due to vagal neuropathy.

In diabetes mellitus associated neuropathy, a reduction in time domain parameters of HRV seems not only to carry a negative prognostic value but also to precede the clinical expression of autonomic neuropathy [(12,13)]

HRV db represents a very sensitive measure of cardiovagal or parasympathetic cardiac function and thus is an important component of the cardiovascular autonomic function tests used in clinical autonomic laboratories. In most autonomic disorders, parasympathetic function is affected before sympathetic function, so HRV db provides a sensitive screening measure for parasympathetic dysfunction in many autonomic disorders[.(14)]

Conclusion

HRV analysis in type 1 diabetes mellitus patients show

Significant reduction in SDNN,RMSSD,NN50 and pNN50

Significant reduction of mean RR, HF and HF nu, compared to that of controls

HRV during one minute controlled deep breathing is a simple non invasive test to detect cardiac autonomic neuropathy. Hence HRV db should be recommended as a screening test for diabetes mellitus patients.

Conflict of Interest: Nil

Sources of Funding: Nil

References

1. Heymans C. Neil E. Reflexogenic Areas of the Cardiovascular System. London JA Churchill 1958
2. Melcher A. Respiratory sinus arrhythmia in man: a study in heart rate regulating mechanisms. Acta Physiol Scand Suppl 1976;435:1-31
3. Wheeler T. Watkins PJ. Cardiac denervation in diabetes. Br Med J 1973;4:584- 586
4. Akselrod S, Gordon D, Ubel FA, Shannon DC, Berger AC, Cohen RJ. Power spectrum analysis of heart rate fluctuation: a quantitative probe of beat-to-beat cardiovascular control. Science 1981;213:220-222
5. Freeman R, Saul JP, Robert MS, Berger RD, Broadbridge C, Cohen RJ. Spectral analysis of heart rate in diabetic autonomic neuropathy. A comparison with standard tests of autonomic function. Arch Neurol 1991;48:185-190
6. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Heart rate variability. Standards of measurements, physiological interpretation and clinical use. Eur Heart J 1996; 17:354-381
7. Fareedabanu AB, Gorkal AR, Narasimha Setty KR. A simple test of one minute heart rate variability during deep breathing for evaluation of sympathovagal imbalance in patients with type 2 diabetes mellitus. Pak J Physiol2011;7(1)33-36
8. P. Zhang, W. Tapp, S. Reisman, B. Natelson, "Respiration Response Curve Analysis of Heart Rate Variability", *IEEE Trans. Biomed Eng*.,April 1997, 44(4):321-325.
9. Dariusz Korczak et al - Evaluation of cardiac autonomic function in insulin dependent diabetic patients using power spectral analysis of heart rate variability, *on Sci Monit*, 1997; 3(4): 530-535.
10. Massimo Chessa, et al Role of Heart Rate Variability in the Early Diagnosis of Diabetic Autonomic Neuropathy in children, *Herz* 2002;27:785–90.
11. Ewing DJ, Martin CN, Young RJ, Clarke BF. The value of cardiovascular autonomic function tests: 10 years's experience in diabetes. *Diabetes care.* 1985:8:491- 498.
12. Kamath MV, Fallen EL. Power spectral analysis of heart rate variability; a non invasive signature of cardiac autonomic function. Crit Rev Biomed Eng 1993; 1:245-311

13. Kitney RI, Byme S, Edmonds ME, Watkins PJ, Roberts VC. Heart rate variability in the assessment of autonomic diabetic neuropathy. Automedica 1982;4:155-167

14. Robert W Shields JR. Heart rate variability with deep breathing as a clinical test of cardiovagal function. Cleveland Clinic Journal of Medicine Volume 76, supplement 2,April 2009, S37-40.