

COMPARISON OF HEART RATE VARIABILITY OF CHRONIC SPINAL CORD INJURY PATIENTS IN SUPINE AND SITTING POSITIONS

Pricilya Sangkoy^a, Hening Laswati Putra^{b*}, Nur Sulastri^c

^aPhysiatrist of Physical Medicine and Rehabilitation Department, Bombana General Hospital, Indonesia

^b Professor of Physical Medicine and Rehabilitation Department, Medical Faculty of Airlangga University, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia, Orchid ID: 0000-0003-4512-4018

^c Physiatrist of Physical Medicine and Rehabilitation Department, Faculty of Medicine of Universitas Airlangga, Airlangga University Hospital, Surabaya, Indonesia, Orchid ID: 0000-0002-4005-0016

*Corresponding Author: lputra04@yahoo.com

Abstract

Background: Sympathetic and parasympathetic activity shift in response to body position changing. Spinal cord injury (SCI) patients have problems controlling autonomic functions occurs as a result of an imbalance between the sympathetic and parasympathetic nervous systems. Despite the fact that changing body position is often used in SCI rehabilitation, few studies have compared the autonomic activity of SCI patients at different body positions. Heart rate variability (HRV) can be used to invasively assess cardiac autonomic modulation. This study aims to obtain information about the autonomic modulation features of SCI patients in supine and sitting positions using HRV measurements.

Methods: This study was a cross-sectional study approach. Participants of this study were 14 chronic SCI patients with injury durations more than a year. Measurement of HRV is using Polar H10 (1B56EB2E). HRV measurements in the subjects of this study were Root Mean Square of the Successive Differences (RMSSD) and Low Frequency/High Frequency (LF/HF) ratio in supine and sitting positions.

Results: There was a significant difference in the value of RMSSD in chronic SCI patients from supine to sitting position (p 0.019). There was no significant difference in the value of LF/HF ratio in chronic SCI patients from supine to sitting position (p 0.408).

Conclusions: Parasympathetic activity (RMSSD) decreased significantly in chronic SCI patients due to postural changing from supine to sitting position. Despite the fact that sympathetic activity is disrupted in SCI patients, the sympathovagal balance can still be maintained with changes in body position.

Keywords: Heart rate variability, Chronic, Spinal cord injury, Supine, Sitting

1. Introduction

The incidence of SCI is about 0.019 percent to 0.088 percent per year from the data of 35 to 53 million people in the world. Based on the data from 2014-2017, a total of 442 patients with vertebral fractures were treated at Dr. Soetomo General Academic Hospital Surabaya (1). Spinal cord injury causes several disorders such as motor, sensory and autonomic disorders that require multidisciplinary management (2,3). One of the autonomic disorders in SCI patients is a disorder of autonomic control of the cardiovascular system (4,5). This autonomic disorder occurs as a result of an imbalance between the sympathetic and parasympathetic nervous systems. This autonomic disturbance causes SCI patients to have a tendency to suffer from cardiovascular diseases such as arrhythmias, heart failure, and myocardial infarction 4 times greater than their peers who are not affected by SCI (6). These cardiovascular disorders are important because they cause high morbidity and mortality in SCI patients. The prevalence of death from cardiovascular complications reaches up to 30 percent of deaths in SCI patients (3, 34).

The most common post-SCI cardiovascular complication is shock neurogenic, orthostatic hypotension, hemodynamic disorder, bradycardia and arrhythmias (7-9). Body position significantly influences cardiac autonomic changes in humans. In healthy adults, autonomic balance changes significantly between supine and vertical (standing or sitting) positions. Sympathetic function is dominant in the vertical position, while vagal function is dominant in supine position. However, few studies have compared the cardiac autonomic activity of SCI patients in different body positions, even though changing body position is often done in the rehabilitation of SCI patients (10). The inability to maintain sympatho-vagal balance with body position changes can lead to orthostatic hypotension in SCI patients. However, an excessive increase in sympathetic activity causes autonomic dysreflexia to occur (3,11,12).

Based on the description above the aim of this study was to obtain information about the differences in features of cardiac autonomic modulation in SCI patients in supine and sitting positions using HRV measurements. Heart rate variability is a noninvasive tool for assessing the autonomic nervous system (13,14). A low HRV value is a marker of the risk of cardiovascular disease (15,16). Detection of autonomic dysfunction in individuals with SCI is very important for determining appropriate management, assessing physical function and general health in SCI patients (17).

2. Methods

2.1 Participants and Study Design

This research is an observational analytic study with a cross sectional study approach to determine the difference in heart rate variability of chronic SCI patients in lying and sitting positions. This research site is at Physical Medicine and Rehabilitation Outpatients Clinic of Dr. Soetomo Surabaya Hospital. Our research was conducted from September 2020 to July 2021.

The study population was SCI patients who visited the Physical Medicine and Rehabilitation Outpatients Clinic of Dr. Soetomo Surabaya Hospital, who met the inclusion and exclusion criteria. The sample size in this study was 14 samples. Inclusion criteria included patients with chronic SCI (at least one year after the incident), injury level was at C3 and below, age between 18 to 64 years, the etiology of SCI was traumatic or non-traumatic, regardless of gender, ethnicity or socioeconomic status, the patient uses a spinal orthosis so it is safe and stable while seated, the patient has good communication and cognitive, and the patient is willing to participate in this study by signing the informed consent form after receiving an explanation about the protocol. The exclusion criteria included patients with heart problems, respiratory problems, mental stress/pain, diabetes, and/or decubitus ulcers. Pain can be assessed with the Wong Baker Scale. In addition, stress can be assessed with the DASS21 questionnaire, pregnant patients, allergic to H10 polar electrodes, patients using pacemakers, taking beta-adrenergic blockers or antiarrhythmic drugs.

2.2 Outcome Measurements

Measurement of HRV is using Polar H10 (1B56EB2E) for 5 minutes in a supine position. Then the patient is seated gradually 30°-45°-60°-75°-90°. RMSSD and LF/HF ratio data in supine and sitting position were taken for HRV measurement. RMSSD indicates the parasympathetic activity. LF/HF ratio indicates sympathovagal balance. The data were analyzed using Kubios software (18,19).

Vital signs are checked every increase in the degree of sitting position. Hip flexion position 90° and knee flexion about 45°. The recording of HRV in a sitting position was done after the patient sat 90° for 5 minutes, then recorded HRV in a sitting position for 5 minutes. Before and after recording, vital signs were checked using a sphygmomanometer (Reister®) for blood pressure, pulse oximeter (Elitech® fox-2) for oxygen saturation and pulse. In addition, safety and emergency kit such as oxygen are prepared, and in the event of an emergency such as loss of consciousness, shortness of breath and chest pain, then the action follows the emergency protocol.

2.3 Statistical Analysis

The analysis of patient data is computerized using the SPSS v.24.0. The analysis of differences in HRV in supine and sitting positions, the T test difference test was used for data with normal distribution and Mann Whitney for data not normally distributed. Significant if $p < 0.05$.

3. Results

The sociodemographic and clinical features of the research subjects are shown in table 1, the sampling method is consecutive sampling. Fourteen eligible samples (9 males and 5 females) were recruited in this study who met the inclusion criteria and were willing to participate in this study, with mean age of 38.50 ± 15.79 years old, injury onset of 1.71 ± 0.82 years and body mass index of 23.43 ± 3.78 kg/m².

Table 1: Sociodemographic and Clinical Features

Features		Mean±SD (n=14)	Min-Max
Age (year)		38.5±15.795	17-64
Injury onset (year)		1.71±0.82	1-3
Body mass index (kg/m ²)		23.43±3.78	14.38-29.33
		n (%)	
Gender	Female	5 (35.71)	
	Male	9 (35.71)	
Etiology	Vertebrae fracture	3 (21.42)	
	Central canal stenosis	4 (28.57)	
	Spondylitis TB	3 (21.42)	
	Spondylolisthesis	1 (7.14)	
	AVM	1 (7.14)	
	Tumour	2 (7.14)	
AIS	A	2 (7.14)	
	B	3 (21.42)	
	C	6 (42.85)	
	D	3 (21.42)	
Injury level	Above T6	7 (50)	
	Below T6	7 (50)	

AVM:Arteriovenous malformation, AIS: American Spinal Injury Association (ASIA) impairment scale, SD:Standart Deviation

Assessment of HRV which analyzed was RMSSD and LF/HF ratio. Normality test used the Saphiro-Wilk test showed that the data were not normally distributed, therefore a non-parametric statistical test was used with the Mann Whitney test. Table 2 shows that there was a significant difference in the value of RMSSD in chronic SCI patients from supine to sitting position (p 0.019). There was no significant difference in the value of LF/HF ratio in chronic SCI patients from supine to sitting position (p 0.408).

Table 2: Comparison of RMSSD and LF/HF Based on Body Position

HRV	Body position		p
	Supine (n=14)	Sitting (n=14)	
RMSSD	101.09 $\pm$ 157.77	21.21 $\pm$ 20.47	0.019*
LF/HF	2.79 $\pm$ 3.80	3.97 $\pm$ 5.58	0.408

*Note: significant difference when the value of $p < 0.05$

4. Discussion

There was a significant difference in the value of RMSSD in chronic SCI patients from supine to sitting position from this study. The RMSSD value describes the parasympathetic modulation of the heart (20). Anatomically, regulation of cardiac parasympathetic (vagal) did not affected by spinal cord lesions. The regulation of cardiac parasympathetic anatomically pass through the vagus and glossopharyngeal nerves, which then descend from the brainstem (medulla oblongata) and synapse to the heart, without passing the spinal cord (21). This study found that parasympathetic activity (RMSSD) in the sitting position was lower than in the supine position, indicating that the vagal (parasympathetic) function predominate in horizontal posture (10). In the lying position (supine position), the force of gravity is the same on the chest, abdomen, and legs because these compartments lie in the same horizontal plane. In this position, the pressure and volume of blood are distributed evenly throughout the body (22). Immediately after rising from supine position, upper body blood pressure decreases, the baroreflex will responds by decreasing parasympathetic activity and increasing sympathetic activity (23).

The results in table 2 show that the LF/HF ratio did not differ significantly in either supine or sitting position. The LF/HF ratio is used to describe the cardiac sympathovagal balance (24). The duration of injury in all subjects in this study was more than 1 year. According to Wang (25), this indicates the ability to maintain sympathovagal balance in chronic SCI patients, the ability of the cardiovascular system to maintain homeostasis even when one autonomic component is disturbed. About 1 year after injury, in most SCI

subjects, the neural dysfunction process is fully established and more or less stable in the following years (26).

The research carried out by Claydon and Krassioukov (27) and Liao et al (28) stated that there was no significant change in LF/HF based on changes of body position of chronic SCI patients. Sympathetic nerve function is dominant in vertical posture (10). The ability of the baroreceptors to maintain a relatively constant arterial pressure in the upper body is important when a person changes position from lying to sitting/standing. Immediately after sitting/standing, the arterial pressure in the head and upper body tends to drop, and this reduction in pressure can lead to loss of consciousness. Baroreceptors elicit reflexes directly as a result of this drop in pressure, resulting in the release of a strong sympathetic response throughout the body. This minimizes pressure drops in the head and upper body (23). In this study, the sympathovagal balance did not change significantly with different body positions. Sympathovagal balance was maintained, despite loss of sympathetic modulation in SCI levels of T6 and above (29). Claydon and Krassioukov (27) describe sympathetic oscillations that can occur even in the absence of sympathetic control of the spinal cord, where the LF component may be mediated by parasympathetic mechanisms or because sympathetic pathway damage may be incomplete.

During the measurement, no side effects were reported. Factors that affect HRV measurement such as psychological factors (stress, depression), co-morbidities such as heart problems, respiratory disorders, diabetes, decubitus ulcers, pregnancy, use of pacemakers, consumption of beta-adrenergic blockers or antiarrhythmic drugs, were excluded from the study subjects, therefore it will not affect HRV (30,31).

Several limitations of this study include the ASIA classification and arterial stiffness. Assessment of HRV based on ASIA classification and arterial stiffness were not performed in this study. The study by El-Kotob et al (6) which compared LF/HF found no significant difference in LF/HF in chronic SCI patients based on the ASIA classification. Arterial stiffness can affect baroreflex sensitivity and may be a confounding factor in measuring HRV in this study (32,33).

Based on the results of the research above, it can be concluded that parasympathetic activity decreased significantly in chronic SCI patients due to postural changing from supine to sitting position. Despite the fact that sympathetic activity is disrupted in SCI patients, the sympathovagal balance can still be maintained with changes in body position. Further research is needed to obtain information about the differences in features of cardiac autonomic modulation in SCI patients. Detection of autonomic dysfunction in individuals with SCI is very important for determining appropriate management to prevent morbidity and mortality in SCI patients.

Conflict of Interest: There is no conflict of interest between the authors.

Ethical Approval: This study was approved by the Ethics Commission of Dr. Soetomo General Academic Hospital Surabaya (Approval Date: September 7th, 2020 and Approval Number: 0051/KEPK/IX/2020)

Informed Consent: All participants approved the informed consent form.

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