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Review Article

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Effects of Three Recumbent Postures on Autonomic Nervous System in Patients with Coronary Artery Disease

Wuon-Shik Kim¶, In-Kyoung Hwang, Hyoung-Min Choi

Bio-signal Research Lab., Korea Research Institute of Standards and Science, Daejeon, Korea

Abstract

Because patients with coronary artery disease (CAD) have depressed vagal modulation and the mortality risk from acute myocardial infarction is lower in patients with higher vagal modulation, methods that can increase vagal modulation are desirable in patients with CAD. We intended to inspect the effect of recumbent posture on vagal modulation. By using angiography, 33 patients with abnormal (CAD group) and 33 patients with normal coronary arteries (control group) were studied. The nonlinear as well as the linear characteristics of heart rate variability (HRV) were analyzed on these patients in three recumbent postures: namely, the supine, right lateral decubitus, and left lateral decubitus postures. The lower the normalized high-frequency power (nHF) in the supine or left lateral decubitus posture, the higher the increase in the nHF when the posture was changed from supine or left lateral decubitus to right lateral decubitus in both groups of patients. Right lateral decubitus posture can lead to the highest vagal modulation and the lowest sympathetic modulation among the three recumbent postures in both normal and patients with CAD. Therefore, the right lateral decubitus posture can be used as an effective physiologic vagal enhancer in patients with CAD.

Keywords: Heart rate variability, Recumbent posture, Vagal modulation, Coronary artery disease

Introduction

Recently, the cardiovascular disease including hypertension, atherosclerosis, stroke, coronary artery disease (CAD) is going to be the most fatal disease of Korean due to the westernized eating habits. In patients with CAD, the reduction in the cardiac vagal activity was found to correlate with the angiographic severity, independent of previous myocardial infarction, and the location of diseased coronary arteries.[1] Some authors have reported that the right lateral decubitus posture can lead to the highest vagal modulation among the three recumbent postures in young healthy subjects,[2] in patients with CAD,[3] during the acute phase of myocardial infarction,[4] in patients with chronic heart failure (CHF) by using heart rate variability (HRV) and by using plasma norepinephrine and plasma atrial natriuretic peptide levels,[5,6] and by using preferred recumbent postures.[7] On the contrary, the left lateral decubitus posture may be beneficial in late pregnancy because cardiac vagal activity is least suppressed and cardiac sympathetic activity is least enhanced. However, there have been also the other results that the levels of vagal modulation do not necessarily reflect a change owing to assuming different body posture, but might be the consequence of changed breathing patterns. There are no advantages of cardiac autonomic tone to be gained by placing a person in the recovery posture on one side compared with the other. The effect of right lateral decubitus posture on vagal modulation has been found to be controversial.

¶ Bio-signal Research Lab., Korea Research Institute of Standards and Science, Daejeon 305-600, Korea
wskim@kriss.re.kr

The main reasons are due to the limited method of analyzing heart rate variability (HRV) and the lack of the knowledge on the mechanism of blood-dynamics in three recumbent postures.

In this study, we inspected the effect of recumbent postures on vagal modulation. In patients with normal coronary arteries (Control group) and patients with abnormal coronary arteries (CAD group), the nonlinear characteristics as well as the time and the frequency domains of HRV were analyzed for the three recumbent postures: the supine, right lateral decubitus, and left lateral decubitus postures.

Material and Method

Study sbjects

Coronary angiography was performed by the standard technique, using a Judkins catheter via femoral or radial artery. There were no complications during this procedure in any patients. We defined patients with severe CAD as those with a stenosis of the coronary artery with luminal narrowing of > 50%. The obstruction of vessels with luminal narrowing of > 50%, other than the 3 major coronary arteries, were graded as obstructions of the major vessel from which they arose. Coronary angiograms were always analyzed visually from more than 2 views. The angiographic grading was performed by a cardiologist and an experienced radiologist. In case of any disagreement in the angiographic grading, another cardiologist analyzed the angiographic results. Agreement between 2 out of 3 analyses was accepted as the true extent of CAD. Cases for which there was no agreement among the 3 observers were excluded from further analysis. Informed consent was obtained from the subjects before study.

Heart rate variability analysis

All subjects were prohibited to drink any caffeinated beverages for >12 hours before the electrocardiographic signals recording. Patients were instructed to breathe normally to prevent the variations in the breath period from influencing the HRV. Three recumbent postures were assumed by the patients in random order. At each recumbent posture, before recording electrocardiographic signals, subjects took a 5-min rest to prevent a transient response of autonomic nervous activity due to changing recumbent postures. These signals were recorded at Lead-II channel with electrocardiograph (Model CardioTouch3000, Bionet Inc, Korea) during 5 min, which was recommended as a short term recording by the guidelines of HRV for each of the three recumbent postures. In this electrocardiograph, the measured analog signal was converted to a digital signal with a sampling frequency of 500 Hz and a resolution of 4.88 μV/LSB. The recorded electrocardiographic signals were retrieved afterward to measure the consecutive RR intervals by using software, which was developed during our previous research for the detection of the R waves. Sinus pause and atrial or ventricular arrhythmia were deleted, and the last 256 stationary RR intervals were obtained in each recumbent posture for HRV analysis. The power spectra of 256 RR intervals were obtained by means of fast Fourier transformation. The direct current component was excluded in the calculation of power spectrum to remove the nonharmonic components in the very low-frequency region (<0.04 Hz). The area of spectral peaks within the whole range of 0 to 0.4 Hz was defined as total power, within the range of 0 to 0.15 Hz as low-frequency power, and within the range of 0.15 to 0.4 Hz as high-frequency power, respectively. The normalized low-frequency power (= 100 × low-frequency power/total power) was used as an index of sympathetic modulation; the normalized high-frequency power (= 100 × high-frequency power/total power) as the index of vagal modulation11; and the low- /high-frequency power ratio (= low-frequency power/high-frequency power) as the index of sympathovagal balance.[8] To avoid circadian variation of cardiac autonomic nervous activity, HRV measurements were carried out during a certain period of daytime: from 9: 30 AM to 11: 30 AM. Room temperature and humidity were also maintained at 24 ± 1℃ and 50 ±5% to prevent environmental conditions from affecting cardiac autonomic nervous activity.

Statistical analysis

All analyses had done using SPSS (version 12.0; SPSS Inc., Chicago, Illinois), and p <0.05 was considered statistically significant. Values of HRV measurements were presented as mean ± SD. One-way ANOVA was analyzed for the three recumbent postures.

The ratio of change in nHF from supine to right lateral decubitous posture nHF(R/S) and that of from left to right lateral decubitous posture nHF(R/L) are defined as follows (see Eqs (1) and (2)):

$$nHF\ (R/S) = \frac{nHF_R - nHF_S}{nHF_S} \times 100\ \%$$

(1)

$$nHF\ (R/L) = \frac{nHF_R - nHF_L}{nHF_L} \times 100\ \%$$

(2)

Where nHF(S), nHF(R), and nHF(L) are the normalized power of HF in supine, right lateral, and left lateral decubitous postures, respectively.[9] The nHF(R/S) was used as the indicator for the assessment of the effect on nHF of changing posture from supine to right lateral decubitus. Similarly, the nHF(R/L) was used as the indicator for the assessment of the effect on nHF of changing posture from left lateral decubitus to right lateral decubitus.

The correlations between nHF(R/S) and nHF(S) (or nHF(R/L) and nHF(L)) were assessed by linear regression analysis.

Results

Clinical and hemodynamic characteristics

Noisy data, artifacts, trends, and ectopic beats are the major practical problems encountered in HRV measurements. Because 27 patients had electrocardiogram with serious noise in any one of the 3 recumbent postures and 12 patients had > 5% deletion of ectopic beats due to atrial or ventricular arrhythmia, only 66 of 105 patients were included in this study. Next, 33 of 66 patients were considered to have severe CAD because they had stenosis with luminal narrowing of > 50%. Table 1 shows the basic and hemodynamic data of the control group and the CAD group. Hypertension was defined as systolic blood pressure >140 mm Hg and/or diastolic blood pressure > 90 mm Hg. Hyperlipidemia was defined as total cholesterol >200 mg/dl and/or low density lipoprotein cholesterol >160 mg/dl.

Table 1 Baseline Characteristics of the Control and CAD Groups

	Control Group (n = 33)	CAD Group (n = 33)	p value
Age (yrs)	56 ± 11	60 ± 10	<0.01
Gender (M/F)	13/20	16/17	NS
History (n, %)			
Previous MI	0(0%)	9(27%)	<0.001
Hypertension	17(52%)	24(73%)	<0.005
Diabetes mellitus	9(27%)	8(24%)	NS
Smoking	4(12%)	10(30%)	<0.005
Hyperlipidemia	16(48%)	15(45%)	NS
Medications			
β blocker	4(12%)	16(48%)	<0.001
Calcium antagonist	4(12%)	10(30%)	<0.005
Nitrates	2(6%)	14(42%)	<0.001
ACE inhibitor	5(15%)	14(42%)	<0.01
Digitalis	1(3%)	1(3%)	NS
Aspirin	12(36%)	33(100%)	<0.001
Clinical status			
LVEF (%)	65 ± 11	64 ± 9	NS
NYHA functional Class			
1-vessel disease	0	13(39%)	NA
2-vessel disease	0	12(36%)	NA
3-vessel disease	0	6(18%)	NA

Values are number of patients or mean ± SD. ACE = angiotensin-converting enzyme; LV = left ventricle; MI = myocardial infarction; NYHA = New York Heart Association; NA = not assessed; NS = not significant (p>0.05).

Effect of recumbent posture on HRV

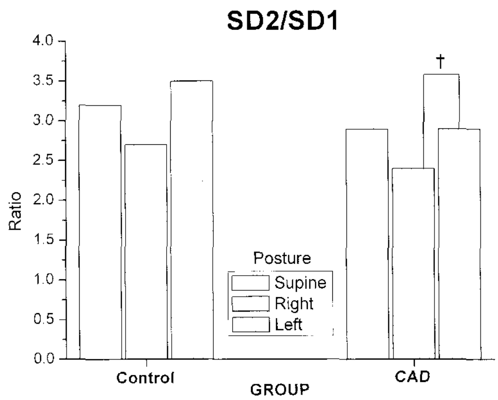
Table 2 shows the effects of the three recumbent postures on HRV in patients from the CAD and Control groups. In control group, the index of sympathetic nerve activity SD2/SD1 in right lateral decubitus posture was significantly lower than that of the left lateral decubitus posture ($p<0.05$). In the CAD group, the indices of sympathetic nerve activity LF/HF and nLF were lower while the index of vagal nerve activity nHF was higher significantly in right lateral decubitus posture than that of the left lateral decubitus posture ($p<0.05$). In the right lateral decubitus posture, the indices of sympathetic nerve activity LF/HF and nLF were lower while the index of vagal nerve activity nHF was higher significantly in CAD group than that of the control group ($p<0.05$). These significant results are described in Fig. 1.

Table 2 The Effects of Three Recumbent Postures on HRV

Parameters	Supine	Right Lateral	Left Lateral
Control group (n = 33)			
SDNN(ms)	27 ± 12	23 ± 10	25 ± 9
SDSD (ms)	18 ± 11	17 ± 8	15 ± 7
TP (ms^2)	689 ± 699	487 ± 356	544 ± 396
VLF (ms^2)	437 ± 576	275 ± 218	344 ± 292
LF (ms^2)	151 ± 166	113 ± 109	132 ± 134
HF (ms^2)	102 ± 101	99 ± 88	68 ± 63
LF/HF	2.5 ± 2.8	1.4 ± 1.2*	2.5 ± 2.5
nLF (nu)	57 ± 22	52 ± 18*	60 ± 21
nHF (nu)	43 ± 22	48 ± 18*	40 ± 21
ApEn	1.07 ± 0.12	1.13 ± 0.10	1.09 ± 0.10
SD1	13 ± 7	12 ± 6	10 ± 5
SD2	36 ± 17	30 ± 13	34 ± 12
SD2/SD1	3.2 ± 1.3	2.7 ± 0.9†	3.5 ± 1.3†
SD1 x SD2	525 ± 455	425 ± 350	374 ± 218
CAD group (n = 33)			
SDNN(ms)	30 ± 13	27 ± 14	26 ± 12
SDSD (ms)	22 ± 12	21 ± 12	19 ± 12
TP (ms^2)	1009 ± 1044	786 ± 1049	770 ± 787
VLF (ms^2)	634 ± 741	436 ± 968	481 ± 589
LF (ms^2)	188 ± 249	163 ± 300	129 ± 139
HF (ms^2)	188 ± 378	187 ± 314	160 ± 434
LF/HF	1.5 ± 1.2	0.9 ± 0.8† *	1.6 ± 1.2†
nLF (nu)	51 ± 21	42 ± 17† *	54 ± 20†
nHF (nu)	49 ± 21	58 ± 17† *	46 ± 17†
ApEn	1.06 ± 0.10	1.09 ± 0.07	1.06 ± 0.07
SD1	15 ± 8	15 ± 8	13 ± 9
SD2	39 ± 18	35 ± 19	35 ± 16
SD2/SD1	2.9 ± 1.4	2.4 ± 0.9	2.9 ± 1.2
SD1 x SD2	692 ± 668	631 ± 739	544 ± 603

†$p < 0.05$: between postures

* $p < 0.05$: between groups



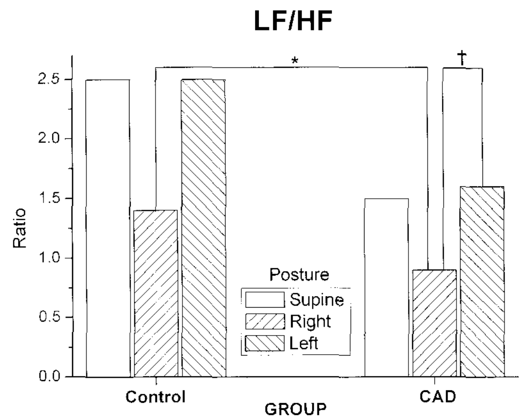


Figure 1 Effect of right lateral decubitus posture on cardiac autonomic nervous activity. The HRV indices of SD2/SD1, LF/HF, and nLF reflect on the sympathetic nerve activity, while the nHF reflects on the vagal nerve activity.

Effect of changing recumbent posture on HRV

When the posture was changed from supine or left lateral decubitus to right lateral decubitus, the percentage of change in nHF were 11.6% for supine (from Eq. 1) and 20% for left lateral decubitus (from Eq. 2) in the control group, whereas 18.4% for supine and 26.1% for left lateral decubitus in the CAD group. The lower the nHF(S) or nHF(L), the higher the increase in nHF(R) when the posture was changed from supine (top panels of Fig. 2-a and Fig. 2-b) or left lateral decubitus (bottom panels of Fig. 2-a and Fig. 2-b), both in control group and in CAD group.

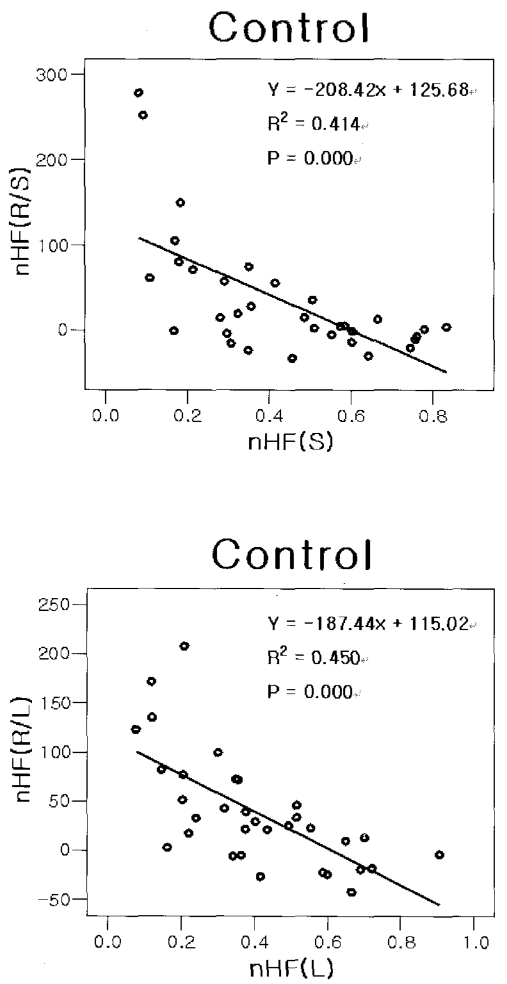
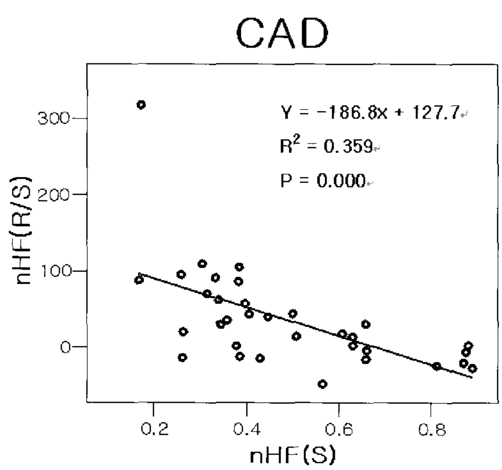


Figure 2-a Effect of changing postures on HRV in control group.



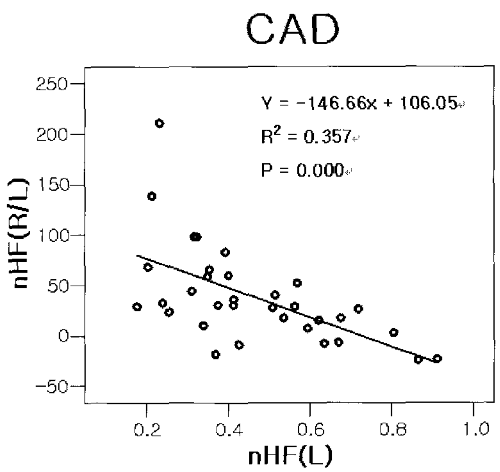


Figure 2-b Effect of changing postures on HRV in CAD group.

Discussion

Right lateral decubitus Posture as a vagal enhancer

Reduced cardiac vagal activity has been reported in patients with coronary artery disease (CAD).[1,10-13] The present study demonstrated that the right lateral decubitus posture can lead to the highest vagal modulation and the lowest sympathetic modulation among the three recumbent postures in both controls and patients with CAD. This finding is similar to the study in young healthy subjects,[2] in patients with severe CAD,[3] in patients with congestive heart failure by using HRV,[5] by using preferred recumbent postures and HRV.[7] The lower the vagal nerve activity in supine or in left lateral decubitus posture, the higher the increase in vagal nerve activity in right lateral decubitus posture when the posture was changed from supine or left lateral decubitus. In this case, the percentage of increase in vagal modulation in the CAD group was greater than that in the control group. Therefore, patients with more severely depressed vagal modulation in the supine or left lateral decubitus posture can benefit more from assuming the right lateral decubitus posture. Because the reduction in vagal modulation correlated positively with angiographic severity, the right lateral decubitus posture is recommended for patients with severe CAD during recumbency.

These results suggest that the right lateral decubitus posture can recover the reduced vagal modulation and suppress the sympathetic over activity in patients with significant CAD. Therefore, the right lateral decubitus posture is desirous, whereas the left lateral decubitus posture is not, in patients with significant CAD when in bed.

Possible mechanisms for recumbent posture effects

Several mechanisms might be responsible for the enhancement of vagal modulation and the suppression of sympathetic modulation when the right lateral decubitus posture was assumed in patients with significant CAD. The position of the heart is higher in the right lateral decubitus posture compared with that of the supine or left lateral decubitus posture (Fig. 3). This causes easy pumping of the blood from the heart to the rest of the body, which results in increased cardiac output, while causing difficulty in venous return. First, the increased cardiac output may cause blood pressure to rise both in the carotid and in aorta, which causes both the carotid sinus reflex and aortic reflex to increase the cardiac vagal nerve activity via cardioinhibitory center in the medulla oblongata. Second, the decreased venous return reduces the blood pressure in the venae cavae, which causes the Bainbridge reflex to decrease the sympathetic activity via cardioacceleratory center in the medulla oblongata. The preference of right lateral decubitus posture in patients with CAD may be a self-protective mechanism of attenuating the imbalance of cardiac autonomic nervous activity.

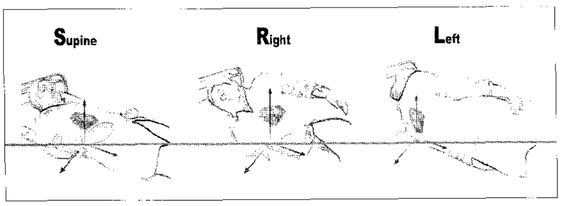


Figure 3 Change of heart position depending on three recumbent postures.

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