ORIGINAL

Clinical training stress and autonomic nervous function in female medical technology students : analysis of heart rate variability and 1/f fluctuation

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Abstract : To evaluate the level of stress induced by clinical training, ambulatory electrocardiograms from 12 healthy female medical technology students were recorded and the spectral components of heart rate variability (HRV) were analyzed as an index of autonomic nervous function. The HF power reflecting parasympathetic tone was significantly decreased at awakening, compared with that before clinical training ($p < 0.01$). The LF/HF ratio reflecting sympathetic activity also significantly increased during, compared with before clinical training ($p < 0.01$). The slope of the spectral density also changed before and during the clinical training from -1.20± 0.04 to -1.09±0.03 ($p < 0.05$). The 1/f fluctuation of HRV appeared comfortable, and tension was apparently adequate while undergoing clinical training. None of these HRV indices statistically changed while asleep. Thus, the students perceived the stress as a comfortable level of tension and analyzing spectral components and 1/f fluctuation of HRV might be a useful method for evaluating study stress. J. Med. Invest. 55 : 227-230, August, 2008

Keywords **:** *stress, HRV analysis, 1/f fluctuation, autonomic nervous function*

INTRODUCTION

Stress influences the hypothalamus via the cerebral limbic system and causes changes in heart rate variability (HRV) through the autonomic nervous system. The amount of exposure to various stresses even in young persons has recently increased, reflecting the increasing complexity of society. We previously analyzed the level of stress induced by endoscopy using HRV and 1/f fluctuation (1-3). Here, we examine the effects of studying upon stress among female medical technology students by measuring changes in autonomic nervous function during clinical training using a nonlinear method of analyzing HRV.

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SUBJECTS AND METHODS

Ambulatory electrocardiogram (ECG)s were recorded from 12 healthy female medical technology students (mean age : 21.9 ± 0.67 years) at this institution to evaluate the autonomic nervous function before and during clinical training. The clinical training of these final-year students was performed from 8 : 45 am to 6 : 00 pm in the clinical laboratory of the Tokushima University Hospital. The students went round all clinical laboratory sections in three months and learned about methods of the medical technology, the quality control of examination data, and the process of order-entry system, etc.

We used an ambulatory ECG recorder (Model

SM-60 ; Fukuda Denshi Inc., Tokyo, Japan) and 24-hour continuous ECGs were analyzed using a Fukuda Holter workstation (DMW-9000H). Heart rate variability (HRV) and 1/f fluctuation were analyzed using the maximal entropy method (MemCalc/CHIRAM ; GMS Co., Tokyo, Japan). The very low (VLF power, 0.003~0.04 Hz), low (LF power, 0.04~0.15 Hz) and high (HF power, 0.15~0.40 Hz) frequency power as well as the LF/HF ratio were calculated by consecutively processing 5-minute RR intervals and used as HRV indices. The total (TF power, 0.0001~0.5 Hz) and ultra low (ULF power, 0.0001~0.003 Hz) frequency power as well as the slope of the spectral density (f^x plot) in which both logarithms are displayed within a frequency range from 0.0001 to 0.01 Hz were calculated by processing successive 180-minute RR intervals while moving the analysis time by 5-minutes. Spectral components of HRV were analyzed as absolute units. Sleep periods were determined from each student's diary and spectral power was compared between sleep (night) and wake (day) period. The students provided oral informed consent and ambulatory ECGs were recorded as part of their clinical training.

All values are expressed as means ± standard error of the mean (SEM). Data were statistically analyzed using Student's paired *t*-test and values of $p<0.05$ were considered statistically significant.

RESULTS

Spectral analysis of heart rate variability

The TF power in healthy female medical technology students over a 24-hour recording period was 8,839±745 msec^2 before and 8,516±1,020 msec^2 during clinical training (N.S.). No changes were significantly different although this change divided the record value while awake and asleep (Table 1). The values of ULF, VLF, and LF power over 24-hours were 4,906±502, 2,483±230 and 886±76 msec^2 before, and 4,589±669, 2,536±258, and 872±114 msec^2 during clinical training, respectively. None of these changes were statistically significant even when individually examined while awake or asleep (Table 1).

On the other hand, the HF power while awake significantly changed before and during training (360±26 vs. 253±38 msec^2, $p<0.01$) although the HF power while asleep did not change (Table 1). The LF/HF ratio while awake also significantly changed before and during training (2.34±0.22 vs. 3.15±0.25, $p<0.01$) although the LF/HF ratio while asleep did not change (Table 1). Figure 1 shows the 3-dimensional power spectra of RR in-

Table 1. Spectral power of HRV before and during clinical training

	Before training	During training	p
TF power (msec^2)			
Waking period (day)	8,372 ± 735	7,147 ± 945	N.S.
Sleeping period (night)	10,217 ± 1,129	12,282 ± 1,475	N.S.
ULF power (msec^2)			
Waking period (day)	4,977 ± 512	4,018 ± 620	N.S.
Sleeping period (night)	4,803 ± 611	6,032 ± 861	N.S.
VLF power (msec^2)			
Waking period (day)	2,168 ± 198	2,084 ± 256	N.S.
Sleeping period (night)	3,356 ± 422	3,835 ± 477	N.S.
LF power (msec^2)			
Waking period (day)	839 ± 93	768 ± 113	N.S.
Sleeping period (night)	994 ± 126	1,183 ± 173	N.S.
HF power (msec^2)			
Waking period (day)	360 ± 26	253 ± 38	<0.01
Sleeping period (night)	1,032 ± 207	1,152 ± 222	N.S.
LF/HF ratio			
Waking period (day)	2.34 ± 0.22	3.15 ± 0.25	<0.01
Sleeping period (night)	1.15 ± 0.17	1.24 ± 0.26	N.S.

Values are means ± SEM, n=12

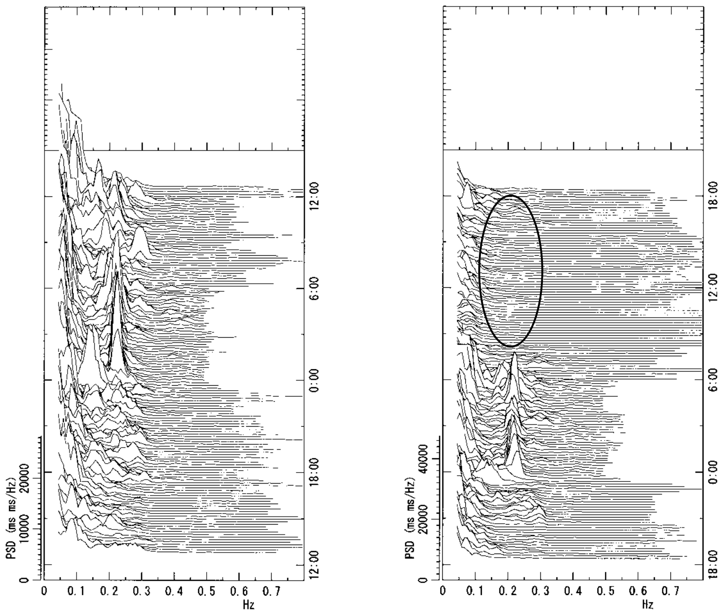

Figure 1 3D Visualization of spectral power in LF to HF components (0.04~0.50 Hz) of HRV. Left and right, before and during clinical training, respectively. Black ellipse, significant decrease of HF power while awake.

tervals over 24-hours from 0.04 to 0.50 Hz (LF and HF components). Black ellipse (right) indicates a significant decrease in the HF power spectrum between 6 AM and 6 PM during clinical training and the circadian rhythm of the HF component at daytime has disappeared.

1/f fluctuation of heart rate

The slope of the f^x plot of the spectral density of HRV while awake also changed before and during clinical training (-1.20 ± 0.04 vs. -1.09 ± 0.03, $p<0.05$) although that while asleep did not change (-0.95 ± 0.03 vs. -0.94 ± 0.04, N.S.) (Fig. 2).

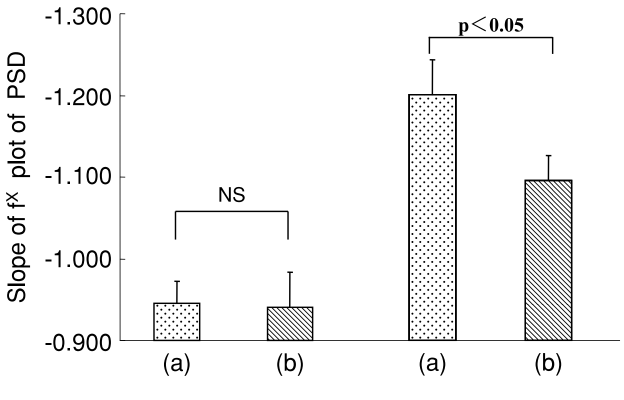

Figure 2 Slope of f^X plot of power spectral density (PSD). Left, asleep ; right, awake.
(a) before, (b) during clinical training. Values are means± SEM, n=12.

DISCUSSION

Changes in the learning environment involved in clinical training exert study stress upon female medical technology students. Various stresses can be non-invasively analyzed using HRV, which measures changes in autonomic nervous function. Therefore, we examined whether or not the students were stressed during clinical training by HRV analysis. Spectral analysis of HRV showed a significant decrease of HF power and a significantly increased LF/HF ratio while awake. The HF power of the HRV is considered a power spectrum that is exclusively mediated by the parasympathetic nervous system (4), and the LF/HF ratio is considered a good marker of sympathetic nervous activity (5). Therefore, stress induced by clinical training induced relative cardiac sympathetic predominance in the students.

Patients with coronary artery disease and survivors of cardiac arrest have a similar autonomic imbalance (6, 7), and markers of vagal inhibition are independent predictive factors of cardiac death in patients with coronary artery disease (8). However, few studies have examined the pathogenesis of changes in autonomic function among young healthy adults. Clinical training might induce transient stress and thus adverse cardiovascular effects upon young students. Among physical education students, the relation between mood disturbance associated with psychological or physical stressors induced by studying and the modifications of autonomic nervous system has been recently reported (9). Hughes, *et al.* also reported that depressed mood is related to the magnitude of decrease in parasympathetic tone during stressors in young healthy students (10).

Therefore, the influence of training was re-evaluated using another HRV index as well as HF and LF power. The 1/f fluctuation is a novel index of HRV and has been used as a marker of pleasant mood (11, 12). When the spectral density of HRV is classified based on the slope of regression line (f^X plot), regression lines of 0, -1, and -2 are classified as white noise, 1/f fluctuation and $1/f^2$ fluctuation, respectively. The present study found that the slope of the spectral density of HRV approximated to 1/f fluctuation during clinical training and that the students appeared to handle the stress as a comfortable tension.

CONCLUSION

The current study demonstrated an autonomic nerve imbalance that originated from increased sympathetic modulation of heart rate in female medical technology students undergoing clinical training. On the other hand, analysis of 1/f fluctuation of HRV revealed a pleasant mood during clinical training. The noninvasive spectral analysis of HRV and 1/f fluctuation of heart rate can continuously evaluate autonomic nervous function for 24 hours and thus might become a powerful means of investigating stress induced by studying. This combination method of HRV analysis might be also applied to evaluate the system of clinical training and to care for the students mentally.

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