(5) HEART RATE VARIABILITY IN DELAYED SLEEP PHASE SYNDROME

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Abstract
The study investigated the heart rate variability (HRV) measures and electrocardiogram (ECG) features during sleep after 24 h total sleep deprivation (TSD) in a mild chronic adult male patient of delayed sleep phase syndrome (DSPS). The findings of mean Heart Rate (HR), mean RR (RRI time series), time domain and frequency domain measures are presented. Bradycardias, sinus pauses and ectopic beats were observed during specific parts of sleep. HRVs suggest a sustained sympathetic and decreased parasympathetic activity in the sleep deprived DSPS patient.

Keywords
Delayed sleep phase syndrome, heart rate variability, autonomic nervous system, sleep

Introduction
HRV is an effective non-invasive method providing quantitative evaluation of the autonomic neural activity modulating the cardiac function. It has been widely used to study the sleep associated changes in sympathovagal balance.¹ We present findings of HRV and ECG manual
inspections from sleep time after TSD in chronic mild male patient of DSPS. His primary complaint was of frequent sleep onset insomnia episodes (last 2 years) and some issues with sleep maintenance. He is non-alcoholic, smoker (10 years) without suggestive symptoms of anxiety, depression and psychosis. The findings of mean Heart Rate (HR), mean RR (RRI time series), time domain measures of the standard deviation of NN intervals (SDNN) and the square root of the mean squared difference of successive NNs (RMSSD), and frequency domain measures of LF%, HF%, LF nu, HF nu, LF/HF nu are presented.

Case report
The ECG data for HRV analysis were from the four polysonographic sleep records performed on a 28 year old Indian male patient of delayed sleep phase syndrome. The sleep records were performed after 24 h total sleep deprivation. The sleep recording time was out of phase with the patients normal sleep time by about 9 h. Single modified ECG lead II comprising torso electrode placement (AASM 2007 manual) was used. Electrodes were placed just beneath the right clavicle and at the midclavicular line (fifth intercostals space) on the left. The HRV analysis was performed using software provided with RMS Quest 32 polysonograph (Recorders and Medicare Systems, Chandigarh, India). Two records were finally selected after manual screening for noise, artefacts, ectopic beats and overall quality. The day 2 record was of shorter total sleep time and differed by 1.9 h from day 1. A total of 96 five minute segments of ECG records were evaluated for HR, time and frequency domain measures of HRV. The selection of 5 min intervals and sampling rate of 256 Hz were in agreement with recommendations of the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. The frequency domain measures were obtained by Lomb Scargle periodogram and Welch’s periodogram methods (Hanning window). The Lomb Scargle periodogram is based on Discrete-time Fourier Transform which needs irregularly sampled series sans interpolation requirement. The Welch’s periodogram is the traditional Fast Fourier Transform requiring interpolation and even resampling of irregularly sampled series.

For each 5 min segment mean HR, mean RR (RRI time series), time domain measures of SDNN and RMSSD, and frequency domain measures of LF%, HF%, LF nu, HF nu, LF/HF nu were analyzed. For evaluating HRV standard categorization of, LF; 0.04– 0.15 Hz, and HF; 0.15–0.4 Hz was used. All of these measures were grouped according to their sleep stages and their means and standard deviations were calculated. The sleep stage groupings consisted of NREM (stage 1 & 2 Non-rapid eye movement sleep), SWS (stage 3 Non-rapid eye movement sleep), SWS/NREM (segments with stage 3 to stage 1/2 transitions or vice versa), NREM/REM (segments with stage1/2 transitions to REM; rapid eye movement sleep or vice versa) and REM (rapid eye movement sleep). Apart from these, ECG having some special features is discussed.

Discussion
The manual inspection of ECG revealed some interesting features. Healthy adults have been reported to have a number of cardiac arrhythmias during sleep like bradycardias, sinus pauses, and premature ventricular contractions. It was observed that both the records had more than one sinus pause incidents (RR intervals >2s duration) in SWS and/or SWS/NREM. These were observed near the end of the first SWS episode.
Figure 1. It shows the RR tachogram, histogram and Poincare plot of a representative 5 min period with sinus pause.

The RR tachogram, histogram and Poincare plot of a representative 5 min period (with sinus pause) are shown in fig.1. Bradycardias were more frequent in the longer record and occurred during NREM, SWS and NREM/SWS. The occurrences of ectopic beats were relatively higher in the latter half of both the records. Some of the representative ectopic beats like premature ventricular contractions have been shown in fig.2.

Figure 2. The figure shows some of the representative ectopic beats.
The HRV analysis results are summarized in table 1.

<table>
<thead>
<tr>
<th>NREM</th>
<th>SWS</th>
<th>SWS/NREM</th>
<th>NREM/REM</th>
<th>REM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day1</td>
<td>Day2</td>
<td>Day1</td>
<td>Day2</td>
<td>Day1</td>
</tr>
<tr>
<td>HR</td>
<td>65.92±1.93</td>
<td>76.67±2.61</td>
<td>70.1±1.67</td>
<td>79.77±2.36</td>
</tr>
<tr>
<td>RR</td>
<td>0.91±0.03</td>
<td>0.78±0.03</td>
<td>0.86±0.02</td>
<td>0.75±0.02</td>
</tr>
<tr>
<td>SDNN</td>
<td>33.88±10.78</td>
<td>34.83±12.57</td>
<td>25.31±5.00</td>
<td>21.47±15.71</td>
</tr>
<tr>
<td>RMSSD</td>
<td>56.36±5.48</td>
<td>46.32±3.27</td>
<td>52.41±5.03</td>
<td>49.15±18.19</td>
</tr>
<tr>
<td>*LF%</td>
<td>16.0±4.89</td>
<td>18.75±6.92</td>
<td>17.5±5.40</td>
<td>18.35±9.32</td>
</tr>
<tr>
<td>*HF%</td>
<td>5.75±3.05</td>
<td>6.25±2.22</td>
<td>6.63±3.20</td>
<td>5.82±0.07</td>
</tr>
<tr>
<td>*LF nu</td>
<td>31.1±10.17</td>
<td>31.97±10.39</td>
<td>32.66±6.79</td>
<td>32.37±5.13</td>
</tr>
<tr>
<td>*HF nu</td>
<td>11.78±7.98</td>
<td>11.28±5.22</td>
<td>12.88±8.21</td>
<td>11.78±10.09</td>
</tr>
<tr>
<td>*LF/HF nu</td>
<td>3.37±1.76</td>
<td>3.83±2.81</td>
<td>3.45±1.84</td>
<td>3.83±1.76</td>
</tr>
<tr>
<td>*LF %</td>
<td>5.47±0.64</td>
<td>6.13±0.47</td>
<td>5.74±0.46</td>
<td>6.62±1.11</td>
</tr>
<tr>
<td>*HF %</td>
<td>1.45±0.20</td>
<td>1.51±0.10</td>
<td>1.48±0.18</td>
<td>1.77±0.95</td>
</tr>
<tr>
<td>*LF nu</td>
<td>79.07±2.06</td>
<td>80.23±1.38</td>
<td>79.5±1.86</td>
<td>79.51±3.67</td>
</tr>
<tr>
<td>*HF nu</td>
<td>21.00±2.08</td>
<td>19.76±1.40</td>
<td>20.41±2.04</td>
<td>20.34±3.71</td>
</tr>
<tr>
<td>*LF/HF nu</td>
<td>3.81±0.43</td>
<td>4.09±0.29</td>
<td>3.93±0.45</td>
<td>4.01±0.59</td>
</tr>
</tbody>
</table>

NREM= stage 1 & 2 Non-rapid eye movement sleep, SWS=stage 3 Non-rapid eye movement sleep, SWS/NREM=epochs with stage 3 to stage 1/2 transitions or vice versa, NREM/REM=epochs with stage 1/2 transitions to REM or vice versa; REM= rapid eye movement sleep; HR=heart rate; RR=interval between two R peaks; SDNN=standard deviation of NN intervals; RMSSD=square root of the mean squared difference of successive NN intervals; LF=low frequency (0.04-0.15); HF=high frequency (0.15-0.4); *Lomb periodogram derived; FFT linear interpolation derived

All the measures showed marked differences, which were related to sleep stage and day of the record. Probably, this is the first report of HRV measures in DSPS; moreover very little information on the sleep HRV after sleep deprivation is available. The mean HR during both NREM and REM was higher in the patient compared to earlier report in healthy individuals. However, this difference may be because of higher the mean age of the control group and moreover, NREM; had only stage 2 NREM sleep data in the study. The Mean RR during stage NREM, SWS and REM were lower in the patient compared to healthy population of similar age group. The SDNN was relatively very low across all sleep stages compared to reported values in healthy people but SDNN during REM on day 1 was in normal range. Lower overall SDNN has been reported in insomniacs.

The RMSSD values were similar on day1; lower on day 2 during NREM and REM vis a vis normal values. The LF % and HF % (LS periodogram) during NREM, SWS and REM was lower than that reported in healthy males but the mean age of volunteers was higher in that study. The LF/HF (LS periodogram) was higher during NREM, SWS and lower during REM compared to healthy males in the literature. Welch’s Periodogram derived LF/HF nu were higher in NREM and lower in REM compared to values in literature for healthy controls.

Mean RR and RMSSD were higher in all of the sleep stage groupings in the record with more sleep time. HF nu (both method) were also higher across all sleep but REM (both records) and NREM/REM (Welch’s Periodogram). SDNN was higher in longer record in all sleep groupings studied but NREM. Mean HR, LF % (Welch’s Periodogram), HF % (Welch’s Periodogram) were lower in all stages in longer sleep record, LF% and LF/HF nu (LS Periodogram) also had similar trend except for...
NREM/REM. LF nu and LF/HF nu (Welch’s Periodogram) were lower in stages grouping involving only NREM sleep but higher in those with REM in longer record. LF/HF, LF nu, LF % values normally follow the trend SWS<NREM (stage 1/2) <REM. However, the DSPS patients’ data in our case had least values of these measures in REM. This seems to reflect impaired parasympathetic recovery and/or reflect prolonged sympathetic drive. Lower values of HF%, HF nu also lend support to the derivation of decreased parasympathetic activity. Higher mean HR, lower RR and SDNN measures may be related to the sustained sympathetic activity. The elevated HR and decreased HRV have been reported in night workers during rest time suggesting prolonged sympathetic activation and sympathovagal imbalance. DSPS has the characteristic features of circadian disruption and therefore, its involvement in HRV factor changes cannot be ruled out. Moreover, the record timing was also not in alignment with the patients’ normal sleeping hours. It would therefore have been more expressive to compare the ECG and HRV characteristics obtained from the normal sleeping hour records.

References: