Original Article

Post- to pre-overnight sleep systolic blood pressures are associated with sleep respiratory disturbance, pro-inflammatory state and metabolic situation in patients with sleep-disordered breathing

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\textbf{Abstract}

Objective: The aim of the current study was to investigate whether changes in post- to pre-overnight sleep systolic blood pressure (SSBP) are associated with sleep respiratory disturbance, pro-inflammatory state, and metabolic situation in patients with sleep-disordered breathing (SDB).

Methods: Anthropometry, sleep polysomnography, biochemical markers, and pre- and post-overnight sleep BP were measured from 263 SDB patients. All SDB patients were further subgrouped into MORNING SURGE (% changes from post- to pre-overnight SSBP >+1SD of this cohort), MORNING DROP (% changes < -1SD), CONSTANT HIGH (% changes within ± 1SD, averaged SSBP > 130 mmHg) and CONSTANT LOW (% changes within ± 1SD, averaged SSBP < 130 mmHg).

Results: BMI, neck circumference, waistline circumference, respiratory disturbance index, arousal index, lowest oxygen saturation, duration of SaO\textsubscript{2} < 90\%, blood glucose, hs-CRP, and metabolic syndrome score in MORNING SURGE and CONSTANT HIGH were significantly greater than those in CONSTANT LOW. Except metabolic syndrome score, all other parameters in MORNING DROP were similar to those in CONSTANT LOW.

Conclusion: Patients with SDB whose post- to pre-overnight SSBPs were elevated or maintained a constant high have more sleep respiratory disturbance, more pro-inflammatory state, and higher metabolic syndrome indices than the rest. Without subdividing into CONSTANT LOW, MORNING DROP, CONSTANT HIGH, and MORNING SURGE, the important pathophysiologic points of SDB patients will possibly be missed.

\begin{abstract}

1. Introduction

Cardiovascular events, such as acute myocardial infarction and cerebrovascular events, occur most frequently in the morning hours when morning blood pressure (BP) increases \cite{1-4}. Other than that, a higher morning BP surge is associated with higher cardiovascular or cerebrovascular risks independent of ambulatory BP and nocturnal BP decreases \cite{3,5}. In a large number of hypertensive patients receiving antihypertensive treatment, blood pressure values remain high during the early morning hours \cite{5}. Nocturnal sleep rather than circadian pattern has been shown to be related to the morning surge in BP, sympathetic activity, and coagulability \cite{4,6}. Changes in blood pressures, such as BP elevations or attenuation, in patients with sleep-disordered breathing are unclear and very controversial.

Sleep-disordered breathing (SDB) is a condition characterized by repeated episodes of apnea and hypopnea during sleep. The prevalence of SDB ranged from 25\% to 27\% in middle-aged men and from 10\% to 16\% in middle-aged women in Asia groups \cite{7}. SDB was shown to be independently associated with hypertension in both men and women \cite{8}. Solid evidence is emerging that the apneic or hypopneic events that occur during sleep lead to hemodynamic changes, including elevated sympathetic tone, decreased stroke volume, lower cardiac output, increased heart rate, worsened systemic hypertension and changes in circulating hormones.

\end{abstract}
that regulate BP, fluid volume, vasoconstriction, and vasodilation [8,9]. The BP changes in patients with SDB may occur in the early morning [3,5] and the increased BP is maintained during the first three to four hours of the morning [10]. Thus, the pre-versus post-overnight sleep BP measurements in patients with SDB are crucial for studying the relationship of BP changes and severity of SDB.

The coexistence of SDB and obesity may have more widespread implications for cardiovascular dysfunction and may contribute to some of the clustering of abnormalities broadly defined as metabolic syndrome [11]. Epidemiologic data also support a complex link among pre-inflammatory state, metabolic syndrome, hypertension, and SDB [11–13]. For example, obstructive sleep apnea, a common subtype of SDB, was shown to be independently associated with a significantly high prevalence of metabolic syndrome [12]. Furthermore, accumulated evidence supports that SDB is independently linked to pro-inflammatory state [14,15], hypertension [8,16], metabolic syndrome [12,13,15], obesity [11,17] and diabetes mellitus [13,18]. Moreover, systolic blood pressure (SBP) is an indicator of cardiovascular risk [19]. However, the effects of sleep systolic BP (SSBP) elevations or attenuation on sleep respiratory disturbance, pro-inflammatory state, and metabolic syndrome in SDB patients are still unclear.

We hypothesized that SDB patients with increased or elevated post- to pre-overnight SSBP have a greater degree of sleep respiratory disturbance, a more pre-inflammatory state, and a worse metabolic situation than SDB patients whose post- to pre-overnight SSBP decreases or maintains a low level. Thus, we prospectively and consecutively recruited non-comorbid subjects with sleep disturbances as the major complaint in our sleep clinics, stratified them according to percentage changes and values of post- to pre-overnight SSBP in our cohort, and compared their sleep respiratory disturbance indices and variables relevant to pro-inflammatory state or metabolic syndrome situation.

2. Methods

2.1. Subjects

Two hundred and sixty-three patients with a wide spectrum of sleep disorders were recruited in the present study, based on 456 patients continuously attended in the Sleep Clinic Chung Shan Medical University Hospital from September 5, 2003 to March 24, 2004, with a chief complaint of sleep disturbance. Inclusion criteria were patients diagnosed with sleep-disordered breathing (SDB) which refers to a wide spectrum of sleep-related breathing abnormalities including snoring, sleep apnea-hypopnea syndrome and upper airway resistance syndrome. The criteria of sleep apnea syndrome or hypopnea syndrome are based on the criteria of the American Academy of Sleep Medicine Manual 2007. Upper airway resistance syndrome is a sleep-disordered breathing syndrome characterized by complaints of daytime fatigue and/or sleepiness, increased upper airway resistance during sleep, frequent transient arousals, and no significant hypoxemia. Except SDB, untreated obesity, untreated pre-hypertension, untreated hyperglycemia, and untreated metabolic syndrome, all diagnosed diseases in the current study were excluded such as cardiovascular diseases, cerebrovascular diseases, neurological diseases, neuromuscular diseases, pulmonary diseases, liver diseases, renal diseases and metabolic diseases. Thereafter, the patients diagnosed with diabetes mellitus and patients receiving medication for hypoglycemia, anti-hyperlipidemia and/or anti-hypertension medication were also excluded. In addition, SDB patients whose duration of total sleep time was less than two hours in sleep laboratory were also excluded. After being approved by Institutional Review Board (IRB), the study was completely scribed to all subjects and all subjects signed written informed consent before participation.

2.2. Questionnaire and anthropometric measurement

All patients were requested to arrive at our sleep laboratory between 8:00 and 9:00 pm and to complete a validated sleep questionnaire and life style questionnaire including smoking and exercise habits. The assessments of anthropometric parameters were performed in all patients with loose-fitting clothing. Body weight and height were measured by an electronically calibrated scale and a calibrated stadiometer, respectively. Neck, waist and hip circumferences were measured in standing position at the end of gentle expiration by calibrated plastic tapes. BMI was calculated as weight divided by height squared (kg/m²).

2.3. Blood pressure measurements

Pre-overnight sleep BPs were measured in wakeful status with at least 15 min quiet supine position before sleep, and post-overnight sleep BPs were measured just before getting out of bed using a Philips V24E modular monitor with noninvasive blood pressure readouts on the right arm in supine position. Mean arterial blood pressure was calculated in the usual manner from the systolic and diastolic blood pressures (i.e., mean blood pressure = 1/3 systolic blood pressure + 2/3 diastolic blood pressure).

2.4. Polysomnography and scoring of sleep

A 12-channel polysomnographic recording system (Rembrandt, Medcare, Amsterdam, Netherlands) was used to assess sleep, respiratory and cardiac variables. The recordings of electroencephalog raphy (C3/A2, C4/A1), electrooculography, and submental electromyography were used to assess sleep state. These signals were used to determine the sleep stage for each 30 s interval of the polysomnographic record, according to conventional criteria [20]. Oxyhemoglobin saturation (pulse oximetry), nasal airflow, nasal pressure (nasal cannulae and pressure sensor), rib cage and abdominal motion were measured to assess episodes of sleep-disordered breathing. Sleep staging and sleep-disordered breathing were subsequently scored using standard techniques. Sleep stages and respiratory events were assessed by trained technicians and reviewed by sleep specialists. All assessed criteria were based on the American Academy of Sleep Medicine Manual. Cessation of airflow for at least 10 s was defined as an episode of apnea. Hypopnea was defined as the nasal pressure signal excursions drop by at least 30% from the sleeping baseline level for 10 s or more that was associated with at least a 4% decrease in arterial oxyhemoglobin saturation. The respiratory disturbance index (RDI) was defined as the average number of episodes of apnea and hypopnea per hour. Arousals were defined as a sudden rise in EEG frequency to alpha or theta activity lasting at least 3 s but less than 15 s preceded by at least 10 s of sleep.

Sleep polysomnographic parameters included total sleep time, RDI, arousal index, lowest oxygen saturation (LOS, %), and duration of O₂ saturation less than 90%, as well as the percentage of total sleep time spent in rapid eye movement (REM) sleep (Stage REM%), Stage 1 (Stage I%), Stage 2 (Stage II%), Stage 3 (Stage III%), and Stage 4 (Stage IV%).

2.5. Blood sampling and biochemical analysis and enzyme immunoassay

Overnight fasting blood samples in patients were drawn from 7:00 to 9:00 am by a trained phlebotomist via a venipuncture of an antecubital vein. The blood samples were drawn and immedi-
ately used for metabolic analysis and enzyme assay. Serum glucose, triglyceride, cholesterol, high density lipoprotein (HDL) cholesterol, and low density lipoprotein (LDL) cholesterol were immediately measured from freshly drawn blood samples. The serum glucose, triglyceride, cholesterol, and HDL were measured by a glucose oxidase autoanalyzer (Analytical Technologies, Farnborough, UK), a triglyceride enzyme autoanalyzer (Bayer Corporation, Tarrytown, NY, USA), a cholesterol oxidase autoanalyzer (Bayer Corporation) and HDL cholesterol (Sigma Diagnostics, St. Louis, MO, USA) on an ADVIA® 1650 chemistry system (Bayer Corporation, Tarrytown, NY, USA) with reagents and calibrators. Low density lipoprotein (LDL) cholesterol was derived using the Friedewald equation. Serum CRP was assayed with a high-sensitivity assay of Immulite high sensitivity CRP (Immulate 2000 Analyzer). The hsCRP, as a skewed variable, was log transformed to achieve a distribution close to normality. Serum uric acid levels were assessed spectrophotometrically using enzymatic methods using Hitachi 747 analyzer (Boehringer Mannheim, Mannheim, Germany).

2.6. Metabolic syndrome scores

The components of metabolic syndrome were set according to the definition of the National Cholesterol Education Program’s Adult Treatment Panel III (ATP III, 2001), which was relatively more useful for clinical practice [21]. A patient is now considered to have metabolic syndrome if any three or more of the following five components are present. The items included (1) fasting plasma glucose >110 mg/dL, (2) systolic blood pressure >130 mmHg or diastolic pressure >85 mmHg, (3) HDL cholesterol <40 mg/dL (male), <50 mg/dL (female), (4) triglycerides >150 mg/dL and (5) central obesity: waist circumference >90 cm in male and >80 cm in female.

2.7. Grouping of overnight BP changes

The percentage of post- to pre-overnight sleep systolic blood pressure (SSBP) changes was calculated as (post- to pre-overnight SSBP)/ pre-overnight SSBP × 100%. In this cohort, the mean changes of post- to pre-overnight SSBP were 1.14 ± 14.3 mmHg (or 0.9% ± 11.1% relative to pre-overnight SSBP). Accordingly, SDB patients whose post- to pre-overnight SSBP changes increased or decreased greater than 11.0% were subgrouped into MORNING SURGE and MORNING DROP, respectively. SDB patients whose post- to pre-overnight SSBP changes within 11.0% and whose averaged values of pre- and post-overnight SSBP < or ≥ 130 mmHg were further subgrouped into CONSTANT LOW and CONSTANT HIGH, respectively. This cut-off point of SBBP, 130 mmHg, was set by the blood pressure criteria according to metabolic syndrome [21].

2.8. Analysis and statistics

Data are expressed as mean ± standard deviation. Statistical analysis was performed with Kruskal–Wallis analysis of variance by ranks test with post-hoc Mann–Whitney U test to examine the differences among subgroups (MORNING SURGE, MORNING DROP, CONSTANT LOW and CONSTANT HIGH). In further statistical analysis, logistic regression was used to adjust potential confounding factors such as age, gender, BMI, smoking habits, and exercise habits. A value of p ≤ 0.05 was considered statistically significant. A log transformation was used if variables were not normally distributed.

3. Results

3.1. BP and anthropometric characteristics among four subgroups of SDB patients

The BP parameters during pre- and post-overnight sleep as well as the post- to pre-overnight SSBP percentage changes in total SDB patients and four subgroups (CONSTANT LOW, MORNING DROP, CONSTANT HIGH, and MORNING SURGE) were shown in Table 1. Age, BMI, neck circumference, and waistline circumference in CONSTANT HIGH and MORNING SURGE were significantly larger than CONSTANT LOW (Table 1). There are no differences of buttock circumference, gender distribution, percentage of smoking and regular exercise habit among these four subgroups (Table 1).

3.2. Sleep characteristics among four subgroups of SDB patients

Sleep polysomnographic parameters in total SDB patients and four subgroups were shown in Table 2. No differences of sleep stages (sleep Stages I and II%, sleep Stages III and IV%, and REM Stage%) were observed among these four subgroups (Table 2).

Table 1

<table>
<thead>
<tr>
<th>Anthropometric characteristic differences among four subgroups with sleep disordered breathing</th>
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</thead>
<tbody>
<tr>
<td>Total SDB</td>
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<tr>
<td>-----------</td>
</tr>
<tr>
<td>Post- to Pre-overnight SSBP, %</td>
</tr>
<tr>
<td>Pre-overnight Sleep SBP</td>
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<tr>
<td>Pre-overnight Sleep DBP</td>
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<tr>
<td>Pre-overnight Sleep MBP</td>
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<tr>
<td>Pre-overnight Sleep SBP</td>
</tr>
<tr>
<td>Pre-overnight Sleep DBP</td>
</tr>
<tr>
<td>Pre-overnight Sleep MBP</td>
</tr>
<tr>
<td>Age, yrs</td>
</tr>
<tr>
<td>Female, %</td>
</tr>
<tr>
<td>Body Mass Index, kg/m²</td>
</tr>
<tr>
<td>Neck Circumference, cm</td>
</tr>
<tr>
<td>Waist Circumference, cm</td>
</tr>
<tr>
<td>Buttock Circumference, cm</td>
</tr>
<tr>
<td>Smoking, %</td>
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<tr>
<td>Regular Exercise Habit, %</td>
</tr>
</tbody>
</table>

SDB, sleep disordered breathing; n, number of subjects; SSBP, sleep systolic blood pressure; SBP, systolic blood pressure; DBP, diastolic blood pressure; MBP, mean blood pressure; P < 0.05; P < 0.01, when comparison between two subgroups in ( ).

* Kruskal–Wallis test.

b Pearson Chi-Square test.

c Mann-Whitney U test.
contrast, higher RDI, higher arousal index, lower lowest oxygen saturation, longer duration of SaO2 < 90% were found in CONSTANT HIGH and MORNING SURGE compared with CONSTANT LOW or MORNING DROP (Table 2).

3.3. Biochemical characteristics among four subgroups of SDB patients

There are no differences of total cholesterol, LDL, and serum uric acid among these four subgroups (Table 3). Higher glucose, higher triglycerides and lower HDL were found only in CONSTANT HIGH compared with CONSTANT LOW or MORNING SURGE. The hsCRP, log hsCRP, and metabolic syndrome scores (BP excluded or BP included) in CONSTANT HIGH and MORNING SURGE were significantly increased compared with CONSTANT LOW or MORNING DROP (Table 3).

4. Discussion

The most important clinical implication in the current study is that SDB patients with MORNING SURGE, though their averaged daytime SBP is within normal range, is often overlooked because they might be free of “hypertension” diagnosis, but these patients actually carry risks of pro-inflammatory state, sleep respiratory disturbance, and metabolic syndrome similar to those in CONSTANT HIGH. Our major findings show that individuals in the CONSTANT HIGH and MORNING SURGE groups are associated with relatively older age, higher BMI, larger neck circumference, wider waist circumference, higher RDI, higher arousal index, lower lowest oxygen saturation (LOS), longer duration of SaO2 < 90%, higher hs-CRP, and higher metabolic syndrome scores (BP excluded or included) in MORNING SURGE, CONSTANT HIGH, and MORNING SURGE were higher than CONSTANT LOW (Table 4).

After adjusting factors of age, gender, BMI, smoking, and exercise habit, the RDI remain significantly higher in CONSTANT HIGH and MORNING SURGE than in CONSTANT LOW or MORNING DROP; metabolic syndrome scores (included or excluded BP factor) in MORNING DROP, CONSTANT HIGH, and MORNING SURGE were higher than CONSTANT LOW (Table 4).

Table 2
Sleep characteristic differences among four subgroups with sleep disordered breathing

<table>
<thead>
<tr>
<th>Total SDB</th>
<th>CONSTANT LOW</th>
<th>MORNING DROP</th>
<th>CONSTANT HIGH</th>
<th>MORNING SURGE</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n = 263)</td>
<td>(n = 138)</td>
<td>(n = 34)</td>
<td>(n = 63)</td>
<td>(n = 28)</td>
<td></td>
</tr>
</tbody>
</table>

Stage 1 + Stage 2, %
70.3 ± 42.7 76.3 ± 84.1 68.0 ± 18.8 0.175
Stage 3 + Stage 4, %
4.4 ± 6.5 77.6 ± 36.2 7.5 ± 5.0 0.061
Rapid eye movement, %
25.4 ± 6.1 28.2 ± 9.2 9.6 ± 5.1 0.056
RDI events/hr
25.5 ± 25.0 19.9 ± 21.0 16.2 ± 17.4
log RDI
1.17 ± 0.50 1.08 ± 0.46 1.02 ± 0.42
Arousal Index, events/hr
37.6 ± 19.5 42.7 ± 20.9
Lowest oxygen saturation, %
82.86 ± 16.9 79.5 ± 17.5
Duration of SaO2<90%, min
12 ± 34 22.1 ± 47.4

Table 3
Biochemical characteristics among four subgroups with sleep disordered breathing

<table>
<thead>
<tr>
<th>Total SDB</th>
<th>CONSTANT LOW</th>
<th>MORNING DROP</th>
<th>CONSTANT HIGH</th>
<th>MORNING SURGE</th>
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<td></td>
</tr>
</tbody>
</table>

Glucose, mg/dL
104.7 ± 29.7 108 ± 39 106 ± 23 <0.0001
Triglyceride, mg/dL
121.3 ± 87.5 116 ± 107 108 ± 45 <0.0001
Cholesterol, mg/dL
183.4 ± 35.3 191 ± 35 182 ± 32 0.223
HDL, mg/dL
46.0 ± 13.6 41.5 ± 13.3 41.9 ± 14.4 0.001
LDL, mg/dL
118 ± 33 113 ± 90 116 ± 32 0.511
hs-CRP, mg/dL
0.19 ± 0.39 0.25 ± 0.43 0.40 ± 0.42 <0.012
log hs-CRP, mg/dL
-1.06 ± 0.51 -1.14 ± 0.50 -0.89 ± 0.61 <0.012
Uric acid, mg/dL
5.99 ± 1.90 6.40 ± 2.15 6.27 ± 1.66 0.071
MS score (BP excluded)
1.62 ± 1.04 1.28 ± 1.10 1.95 ± 1.28 0.0001
MS score (BP included)
2.17 ± 1.30 2.18 ± 1.10 2.56 ± 1.36 <0.0001

Table 4
RDI and metabolic syndrome score among SDB subgroups adjusted by age, gender, BMI, smoking, and exercise habit

<table>
<thead>
<tr>
<th>MORNING DROP</th>
<th>CONSTANT HIGH</th>
<th>MORNING SURGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDI (N=126)</td>
<td>1.02(1.00–1.04)</td>
<td>1.00(1.00–1.05)</td>
</tr>
<tr>
<td>1.04(1.01–1.07)*</td>
<td>1.04(1.01–1.07)***</td>
<td></td>
</tr>
<tr>
<td>MS Score (BP excluded)</td>
<td>1.98(1.22–2.97)</td>
<td>1.67(1.06–2.57)*</td>
</tr>
<tr>
<td>MS Score (BP included)</td>
<td>2.20(1.49–3.24)**</td>
<td>1.65(1.02–2.67)**</td>
</tr>
</tbody>
</table>

SDB, sleep disordered breathing; BMI, body mass index; RDI, respiratory disturbance index; BP, blood pressure; Values, Odds ratio (95% CI); *P < 0.05; **P < 0.01; **P < 0.001; non-significant, when compared with CONSTANT LOW; #P < 0.05; ##P < 0.01; NS(MD) non-significant, when compared with MORNING DROP.
or CONSTANT HIGH groups, certain overnight stressors during sleep, such as altered sympathetic activity, hypoxia and hormones, may drive blood pressure surge or make it difficult to calmdown high sleep BP. The Framingham heart study reported that systolic BP more accurately described the risk of all complications and was significantly more informative than diastolic BP for predicting strokes and coronary heart diseases [19,23]. Lessening systolic hypertension definitely lowers the rate of strokes, heart failure, coronary heart disease, and even all-cause mortalities [22,24]. Therefore, in terms of clinical implications, we only focused on observing the changes of systolic BP of pre- and post-sleep in our SDB patients and investigating whether such simple values of post-to pre-overnight sleep systolic BP changes postulate to potential severities of sleep respiratory disturbance, pro-inflammatory state and metabolic abnormalities.

All subjects in these four subgroups, even in the CONSTANT HIGH group, who attended the Sleep Clinics were included without “diagnosed hypertension” or “diagnosed metabolic syndrome.” Therefore, the measurements of pre- and post-sleep overnight BP appear to be an easy way to screen high risks of “poor sleep respi- ratory disturbance,” “early hypertension,” or “early metabolic syn- drome.” The detailed mechanism explaining why sleep apnea, nocturnal intermittent hypoxia, or sympathetic tone changes con- tribute to the development of morning BP surge and/or resistant hypertension remains unclear. Spontaneous hypertensive rats had poor sleep quality and higher sleep-specific sympathetic vaso- motor activity [25,26].

OSA, a popular subtype of SDB, is associated with systemic inflammation, characterized by elevated levels of certain potent pro-inflammatory mediators, such as TNF-alpha, IL-6, reactive oxy- gen species, adhesion molecules, and C-reactive protein, all of which may predispose one to the development of cardiovascular complications [27,28]. The hs-CRP is a stable marker of inflamma- tion, an active player in atherogenic process and a cardiovascular risk predictor [29]. The present findings may provide an important link among systemic inflammation, hypertension, and SDB.

A cluster of abnormalities defines metabolic syndrome includ- ing hyperglycemia, lowered high density lipoprotein cholesterol, central obesity, hypertriglyceridemia, and pre-hypertension [12,13,15]. Evidence accumulated from basic science to clinical studies suggests that SDB patients may aggravate pathophysiolog- ical conditions to obesity or metabolic syndrome [30]. Previous data suggest that SDB was independently associated with cardio- vascular risk factors that comprise metabolic syndrome [12]. These previous and current data show that SDB patients with stronger overnight BP perturbations or without capability to attenuate high BP via night sleep might suffer higher prevalence of metabolic syndrome.

The morning-to-evening increase from lowest level to highest morning levels in systolic blood pressure by >55 mmHg were shown to be independently associated with risk of stroke in old hypertensive patients [3,31]. Two studies have reported that SDB patients experienced less BP fall during sleep plus BP maximization in the morning by using 24 h BP measurement [32,33]. Eventually, sleep itself rather than circadian rhythm, is responsible for fluctuations of BP, sympathetic activity, and coagulability [4]. All these reports might postulate that BPs, especially in systolic BP, before, during and after sleep might be the crucial indicators for cardiovascular and cerebrovascular morbidity and mortality [4,6]. The previous re- ports and our current findings might reflect that BP measurements before and after sleep periods could be an alternative implication for long term follow-up for cardiovascular diseases.

Indeed, it is not novel to detect pre- and post-overnight sleep BP for SDB patients at home or in a sleep laboratory. However, very limited studies did take overnight sleep BP changes into account to clarify the temporal effects of SDB on hemodynamics. A decade ago, pre- to post-night sleep BP differences in SDB patients were observed by Hoffstein et al. who found that these differences were very small, but statistically significant, in SDB patients with severe sleep apnea and hypoxemia (RDI >50 and lowest O2 saturation <70%) [10]. After all, these differences disappeared when the groups were matched for age and body mass index [10]. Without subdividing the subjects of into “CONSTANT LOW,” “MORNING DROP,” “CONSTANT HIGH” and MORNING SURGE, as we did in the current study, the interesting physiological points of SDB with overnight blood pressure changes might be missed.

With regard to therapeutic application, our findings may further propose that pre- and post-overnight sleep BP values can offer one clinical implication to potentially predict sleep respiratory distur- bance, pro-inflammatory state and the trend toward metabolic syndrome in SDB patients. For overall clinical implications we may further suggest that simple BP measurements before and after nocturnal sleep should be performed by self-measurement at home. The simple BP measurements might be the simplest predic- tor for sleep respiratory disturbance, pro-inflammatory state and metabolic situation. Whether or not post- to pre-overnight SSBP surge is the early phenomenon for consequential daytime hyper- tension might be worthy of further study.

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