**Polysomnographic Profile in a Sleep Laboratory in Kolkata: A Retrospective Analysis of 714 Cases**

AG Ghoshal*, Supriya Sarkar**, DJ Roy+, RK Das+, Mita Ray+

**Abstract**

In this retrospective analysis, all patients (n = 714; male = 590; female = 124 and female/male ratio = 1: 4.76) came to Pulsar, a sleep laboratory of Kolkata, for polysomnography during ten years period were analyzed. More than half (62.46%) cases were between 41-60 years and 14.43% cases between 61-80 years age group. Fifty-two percent cases were referred by pulmonologists, followed by internists (15%), and 7% were self referred. Though obstructive sleep apnea was responsible for increased cardiovascular mortality and resistant hypertension, only 4% cases were referred by cardiologists. We observed hypertension as co-morbidity in 52.63% cases and ischemic heart disease in 22.83% cases. Snoring was the presenting complain in 98.28% cases, choking was present in 48.88% cases and excessive daytime sleepiness was found in 96.64% cases. Females showed comparatively higher frequency of sleep disordered breathing than males with increasing basal metabolic rate. Nightfall of SpO2 below 90% was observed in 86.97% of study population. We found abnormal respiratory disturbance index (>5 / hr of sleep) in 95.87% of our patients, normal respiratory disturbance index (≤5 / hr of sleep) in 9.94% cases and isolated nocturnal hypoxemia in 5.46% cases (74.36% of the last category having obstructive airway disease). Snoring with respiratory disturbance index (RDI) ≤ 5/hr was observed in 102 cases, of them 81.37% had simple snoring without significant arousal whereas 18.63% had multiple sleep fragmentation. We estimated that 84.06% of males, 87.10% of females and 84.59% of study population had obstructive sleep apnea.

Split night polysomnography was performed in 362 cases, and of them 15.47% cases could not tolerate continuous positive airway pressure (CPAP) due to local or psychological reasons. In the present one time split-night CPAP titration study, we could not correct OSA in 19.06% subjects. Inadequate correction of hypoxemia due to co-morbid condition like COPD, asthma, obesity, hypothyroidism was the main responsible factor (49.28%). Treatment with CPAP was effective in 68.23% cases in first attempt. More than half of the cases (62.42%) required 10 cm of H2O or less CPAP.

**Introduction**

The word polysomnography (PSG), derived from the Greek roots “poly,” meaning many, “somno,” meaning sleep, and “graphy” meaning to write, refers to multiple tests performed on patients while they sleep. PSG correlates stages of sleep with respiratory air flow and respiratory effort, and generally includes monitoring of the patient's airflow through the nose and mouth, blood pressure, electrocardiographic activity, blood oxygen level, brain wave pattern, eye movement, and the movement of respiratory muscle and limbs. PSG monitors sleep stages, respiratory effort, oxygen saturation, heart rate, body position and limb movements.

PSG is an overnight test to evaluate sleep disorders such as sleep apnea. Sleep apnea may be obstructive sleep apnea (OSA), central sleep apnea (CSA) and mixed. OSA is the commonest type, in which the muscles of the soft palate, tongue and throat relax and close off the airway during sleep. OSA is usually manifested by snoring, choking, arousal, fragmentation of sleep and excessive daytime sleepiness (EDS). OSA was first reported by Guillimault et al. OSA is diagnosed by the apnea-hypopnea index (AHI) or respiratory disturbance index (RDI). An abnormal AHI (greater than 5 events per hour of sleep) accompanied by EDS is the hallmark for the diagnosis of OSA. Continuous positive airway pressure (CPAP) is the treatment of choice for OSA patients. Split night PSG titrates CPAP to individual needs.

Wisconsin Sleep Cohort Study on 602 men and women aged 30-60 years estimated that the prevalence of sleep disordered breathing was 9% in women and 24% in men on the basis of more than 5 AHI events per hour of sleep. Of the 9% women, 22.6% had daytime sleepiness, and of the 24% men, 15.5% had daytime sleepiness. Thus, the prevalence of OSA in the middle-aged adult population was estimated to be 2% in women and 4% in men.

In this present retrospective study, we analyzed the PSG data collected over a decade in a sleep laboratory in Kolkata to assess the demographic pattern, referral pattern, presence of co-morbidities, OSA severity, and effect of CPAP on diagnosed OSA.

**Material and Methods**

All patients came to Pulsar, 224 Rashbihari Avenue, Kolkata-19, the only sleep laboratory of Kolkata for PSG, either referred by doctors or self referred during the period July 1998 to June 2008 (ten years period) were analyzed in the study. Analysis was done by standard statistical methods.

Every patient was subjected to detail history regarding snoring, choking, EDS (based on Epworth Sleep Scale), fatigue, intellectual function, gastro-esophageal reflux etc. Their first degree relatives including spouses were also subjected to questionnaire for confirmation of their sleep disturbances. Patients were then subjected to detail clinical examination that included height, weight, blood pressure measurement, ENT check up. Routine blood and biochemistry were done in all cases which included blood sugar, thyroid profile. X-ray chest, ECG,
spirometry and echocardiography were done in selected cases.

The patients were on their usual medications. Before the patient went to sleep, the procedure was explained to them. Monitors used were:

i. Electroencephalography (EEG) — to record his or her brain wave activity, to establish different stages of sleep as well as to detect seizures.

ii. Continuous electro-oculography (EOG) — to record eye movement and to identify rapid-eye-movement (REM) sleep.

iii. Thermisters (a heat-sensitive device) — to measure the air flow through the patient’s nose and mouth and to detect episodes of apnea (stopped breathing), or hypopnea (inadequate breathing).

iv. Pulse oximetry — to measure the saturation of oxygen in the blood (SPO2) and to assess the degree of oxygen starvation during episodes of hypopnea or apnea.

v. Electrocardiogram (ECG) — to record the electrical activity of the patient’s heart and to detect cardiac arrhythmias.

vi. Chest wall and abdominal electrodes — to record respiratory movement of thorax and abdomen.

vii. Blood pressure cuff — to measure blood pressure (BP).

viii. Limb electrodes— to monitor the movement of limbs during sleep.

The data recorded in computer were analyzed to detect apnea, hypopnea, AHI, RDI, and other abnormalities. CPAP therapeutic trial was given with titration of the pressure of CPAP in patients with OSA.

Definitions used in the study:

i. Apnea — is defined as the absence of airflow for ≥ 10 seconds

ii. Hypopnea — is defined as reduction in respiratory effort with ≥ 4% oxygen desaturation

iii. AHI — is defined as the sum of apneas and hypopneas per hour of sleep

Table 1: Distribution of patients according to age and gender (n = 714)

<table>
<thead>
<tr>
<th>Age groups (Years)</th>
<th>Male</th>
<th>Female</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>12</td>
<td>07</td>
<td>19(2.66%)</td>
</tr>
<tr>
<td>21-40</td>
<td>122</td>
<td>19</td>
<td>141(19.75%)</td>
</tr>
<tr>
<td>41-60</td>
<td>371</td>
<td>75</td>
<td>446(62.46%)</td>
</tr>
<tr>
<td>61-80</td>
<td>82</td>
<td>21</td>
<td>103(14.23%)</td>
</tr>
<tr>
<td>81-100</td>
<td>03</td>
<td>02</td>
<td>05(0.70%)</td>
</tr>
<tr>
<td>Total (%)</td>
<td>590(82.63%)</td>
<td>124(17.37%)</td>
<td>714</td>
</tr>
</tbody>
</table>

Table 2: Distribution of patients according to specialists who have referred the cases (n = 714)

<table>
<thead>
<tr>
<th>Referring specialist</th>
<th>No of cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonologist</td>
<td>372</td>
<td>52.10%</td>
</tr>
<tr>
<td>Internist</td>
<td>107</td>
<td>14.99%</td>
</tr>
<tr>
<td>Oto-rhino-laryngologist</td>
<td>63</td>
<td>08.82%</td>
</tr>
<tr>
<td>Neurologist</td>
<td>29</td>
<td>04.06%</td>
</tr>
<tr>
<td>Cardiologist</td>
<td>28</td>
<td>03.92%</td>
</tr>
<tr>
<td>Endocrinologist</td>
<td>07</td>
<td>00.98%</td>
</tr>
<tr>
<td>Psychiatrist</td>
<td>50</td>
<td>07.00%</td>
</tr>
<tr>
<td>Self referred</td>
<td>714</td>
<td>99.99%</td>
</tr>
</tbody>
</table>

Table 3: Distribution of addictions and presenting symptoms according to specialists who have referred the cases (n = 714)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonologist</td>
<td>214</td>
<td>46</td>
<td>368</td>
<td>174</td>
<td>358</td>
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<tr>
<td>Internist</td>
<td>49</td>
<td>24</td>
<td>107</td>
<td>56</td>
<td>104</td>
</tr>
<tr>
<td>Oto-rhino-laryngologist</td>
<td>24</td>
<td>13</td>
<td>61</td>
<td>32</td>
<td>59</td>
</tr>
<tr>
<td>Neurologist</td>
<td>27</td>
<td>12</td>
<td>58</td>
<td>21</td>
<td>57</td>
</tr>
<tr>
<td>Cardiologist</td>
<td>21</td>
<td>14</td>
<td>29</td>
<td>15</td>
<td>29</td>
</tr>
<tr>
<td>Endocrinologist</td>
<td>09</td>
<td>04</td>
<td>26</td>
<td>17</td>
<td>27</td>
</tr>
<tr>
<td>Psychiatrist</td>
<td>06</td>
<td>05</td>
<td>06</td>
<td>05</td>
<td>07</td>
</tr>
<tr>
<td>Self referred</td>
<td>38</td>
<td>16</td>
<td>50</td>
<td>29</td>
<td>49</td>
</tr>
<tr>
<td>Total (%)</td>
<td>387(54.20)</td>
<td>134(18.77)</td>
<td>706(98.88)</td>
<td>349(48.88)</td>
<td>690(96.64)</td>
</tr>
</tbody>
</table>

Results and Analysis

We performed PSG in 714 persons in our sleep laboratory during the period, and of them 590 (82.63%) were male, 124 (17.37%) were female and 1: 4.76 was the female male ratio. Nineteen (2.66%) subjects were below the age of 20 years, 141 (19.75%) subjects were between 21-40 years, 446 (62.46%) subjects were between 41-60 years, 103 (14.43%) subjects were between 61-80 years and 5 (0.7%) subjects were above the age of 80 years (Table 1). More than half of the cases 372 (52%) were referred by pulmonologists, followed by internist 107 (15%) cases, Oto-rhino-laryngologist 63 (9%) cases, neurologist 58 (8%) cases, cardiologist 29 (4%) cases, endocrinologist 28 (4%) cases and psychiatrist 7 (1%) cases. Fifty subjects (7%) came by themselves, self-referred (Table 2).

In our study population, 64.92% of male cases (383 cases), 3.23% of female cases (4 cases) and 54.20% of total cases (387 cases) were smoker. Addiction to alcohol was found in 130 (22.03%) males, in 04 (3.23%) females and in 134 (18.77%) total cases. Snoring was the presenting complain in 585 (99.15%) cases. Snoring was the presenting complain in 585 (99.15%) cases. All self referred cases had snoring and all except one had EDS. All cases referred by internist had snoring and all except one had EDS. All cases referred by cardiologist had snoring and EDS. Snoring was the presenting symptoms in all cases referred by internist.

Hypertension (HTN) was the commonest co-morbid condition, and found in 376 (52.63%) of the total population. Ischemic heart disease (IHD) was observed in 163 (22.83%) subjects, hypothyroidism was found in 161 (22.55%) subjects; gastro-esophageal reflux disease (GERD) was complained by 53 (7.42%) subjects; and diabetes mellitus (DM) was associated
in 233 (32.63%) subjects (Fig. 1). Surprisingly obstructive airway disease (OAD) was found in 107 (14.96%) of study population though 52% subjects were referred by pulmonologists.

In the study population (Table 4), 104 (18.31%) men, 12 (9.84%) women and 116 (16.81%) of study population were within normal BMI (below 25 kg/m2); and 239 (42.08%) men, 21 (17.21%) women and 260 (37.68%) total population were overweight (BMI between 25-30 kg/m2). Gross obesity (BMI more than 30 kg/m2) was observed in 225 (59.62%) men, 89 (73.00%) women and 314 (45.50%) of total population. Females showed comparatively higher frequency of sleep disordered breathing (SDB) assessed by EDS (Epworth Sleep Scale Score ≥ 10), with increasing BMI (51.64% of females versus 34.86% of males with BMI between 30-40 kg/m2 and 09.06% of females vs 01.41% of males with BMI more than 45 kg/m2).

Nocturnal fall of SPO2 below 90% was observed in 621 (86.97%) cases. SPO2 between 90-80%, between 80-70% and between 70-60%, between 60-50% and between 50-40% was found in 24.65%, 23.53%, 19.05%, 10.22% and 8.26% cases respectively (Fig. 2). Severe hypoxemia (SPO2 below 40%) during sleep was noticed in 9 (1.26%) cases. In 93 (13.03%) subjects SPO2 remained abnormal RDI (RDI > 5) in 604 (84.59%) of study population. Of them 7 patients had EDS. So, we estimated 84.06% males, 87.10% females and 84.19% of our study population had OSA. Of them 7 patients had mixed obstructive and central sleep apnea.

We performed split night PSG in 362 cases. Fifty six (15.47%) cases could not tolerate CPAP due to several reasons including claustrophobia and local problems. In 69 (19.06%) patients CPAP was not effective at the first attempt. Reasons for ineffectiveness of CPAP titration were inadequate CPAP titration time in 13 (18.84%) cases; predominance of central sleep apnea in 7 (10.14%) cases; Mask leak, even after changing mask available in our center, in 9 (13.04%) cases; inadequate correction of hypoxemia due to co-morbid conditions like COPD, asthma, obesity, hypothyroidism in 34 (49.28%) cases and associated periodic limb movements in sleep (PLMS) in 6 (08.7%) cases. In remaining 247 (68.23%) cases CPAP was successfully titrated. The minimal titration pressure of CPAP required were below 8 cm of H2O in 8.09% of cases, 8 cm of H2O in 15.79% of cases, 9 cm of H2O in 8.99% of cases, 10 cm of H2O in 29.55% of cases, 11 cm of H2O in 5.26% of cases, 12 cm of H2O in 14.57% of cases, 13 cm of H2O in 4.45% of cases, 14 cm of H2O in 3.24% of cases, 15 cm of H2O in 2.02% of cases, 16 cm of H2O in 2.02% of cases and more than 16 cm of H2O in 1.62% of cases (Fig. 3).

Discussion

Diagnosis of sleep apnea is the most important indication of PSG. Other syndromes evaluated by PSG are narcolepsy (people have sudden attacks of sleep), cataplexy (temporary loss of muscle tone), sleep paralysis or hallucinations at the onset of sleep and parasomnias (abnormal behaviors or movements during sleep). OSA is the predominant type of sleep apnea syndrome.2 OSA is a repetitive complete obstruction (apnea) or partial obstruction (hypopnea) of the collapsible part of the upper airway during sleep; the syndrome is associated with excessive daytime sleepiness or chronic fatigue.4 Several studies have shown that OSA is associated with accident risk, cognitive impairment and cardiovascular disorders.3

There is no ‘gold standard’ to diagnose OSA. Traditionally, PSG in an attended setting (sleep laboratory) has been used as a ‘reference standard’ for the diagnosis of OSA. It is believed that PSG in-lab is more accurate than PSG in-home, as AHI measured from portable devices in the home is the sum of apneas and hypopneas per hour of time in bed, rather than of sleep. PSG measures several sleep variables, one of which is AHI or RDI. Often the two terms are used interchangeably. AHI has been widely used to diagnose OSA although with different cut-off levels, the basis of which is unclear. In general, there is poor correlation between PSG variables and clinical variables. A variety of cut-off points of AHI (> 5, > 10, > 15) are arbitrarily used to diagnose and categorize severity of OSA. Generally, an AHI of more than 5 events per hour of sleep is arbitrarily considered abnormal.2 Recently, one study used a therapeutic trial of CPAP to diagnose OSA, taking habitual snorers with daytime sleepiness that did not have any other medical or psychiatric disorders as subjects. Using PSG as the reference
OSA is strongly associated with obesity. It is hypothesized that obese individuals have large deposits of fat in the neck, which causes the upper airway to collapse in the supine position during sleep. A significant reduction (P<0.001) of AHI and CPAP requirement was observed in a 17 ± 10 months follow up study following bariatric surgery in 25 severely obese patients.7

Positional sleep apnea is defined as a 50% reduction in AHI during non-supine sleep in relation to supine sleep. It was estimated that 26% of patients with a positive sleep test had positional sleep apnea. Patients with positional sleep apnea may benefit from positional therapy designed to prevent the supine position during sleep.5

Intuitively, it could be argued that excessive daytime sleepiness in OSA patients would lower attention span and might increase the risk of accidents compared to people who do not have OSA. However, many researchers believe that the associated cardiovascular disorders are more serious consequences of OSA. This has raised awareness on the importance of OSA diagnosis. A higher prevalence of hypertension was observed in severe form of OSA than patients with milder forms of OSA.8 It was hypothesized that OSA can lead to sustained hypertension.9 However, it is not clear that these associations are independent of obesity as in most of these studies patients with higher AHI values also had higher BMI values. In 2000, Peppard et al.11 followed up 893 participants from the Wisconsin Sleep Cohort Study for ≥ 4 years from baseline (end point). They divided them into four groups by baseline values of AHI: (1) AHI = 0; (2) AHI = 0.1 to 4.9; (3) AHI = 5 to 14.9; and (4) AHI greater than 15, and used group 1 as the reference group. After adjusting for baseline hypertension, BMI, alcohol and cigarette use, they found that the odd ratio (OR) of hypertension were higher in groups 2 to 4 compared with group 1 (OR = 1.42 [2 vs. 1], 2.03 [3 vs. 1], 2.89 [4 vs. 1]; P = 0.002 for trend). Marin et al.12 found that new cardiovascular events occurred more frequently in untreated patients with severe OSA compared to healthy men. After adjusting for age, presence of cardiovascular disease, hypertension, diabetes, lipid disorders, smoking status, alcohol use, systolic and diastolic blood pressure, blood glucose, total cholesterol, triglycerides, and current use of antihypertensive, lipid lowering, and anti-diabetic drugs these variables, OR was 2.87 (CI = 1.17, 7.51) for untreated severe OSA group compared to control group. The authors concluded that severe OSA patients are at higher risk of cardiovascular events compared to healthy men, and that CPAP treatment reduces this risk.12

Yaggi et al.13 found that the event rate of stroke or death was 3.48/100 person-years in OSA group, and 1.60/100 person-years in the control group. After adjusting for age, sex, race, smoking status, alcohol consumption, BMI, diabetes, hyperlipidemia, atrial fibrillation, and hypertension, the hazard ratio was 1.97 (CI = 1.12, 3.48). The authors concluded that OSA significantly increases the risk of stroke and death, and the increase is independent of other risk factors. A cross- sectional and longitudinal analysis of the Wisconsin Sleep Cohort study14 concluded that the odds of prevalent strokes were significantly higher in participants with an AHI ≥ 20 compared to participants with an AHI less than 5 (OR = 3.83, CI = 1.17-12.56; P = 0.03) after adjusting for age, sex, BMI, alcohol, smoking, diabetes, and hypertension. Several studies have documented association between sleep disordered breathing and diabetes.15 However, as is the case with hypertension, these associations are based on cross-sectional data and hence provide no evidence for a cause-effect relationship.

CPAP therapy is the treatment of choice for OSA patients. In 2005, Doherty et al.16 reported long-term effects of CPAP on cardiovascular outcomes in OSA patients compared to untreated OSA patients followed for an average of 7.5 years, and found that the survival was significantly decreased in the untreated group (P = 0.009). The authors concluded that CPAP has a protective effect against cardiovascular mortality.

In our analysis, we found snoring in 98.88% subjects and EDS in 96.64% subjects. It is interesting to note that though plethora of literature suggested association of OSA with refractory hypertension, increased risk of cardiac complications and stroke, referral from cardiologist was minimum even less than self referred group. Hypertension was the commonest co-morbidity condition, which was followed by DM and IHD. Though more than 50% cases were referred by pulmonologist OAD was associated in 14.96% cases. We observed a distinct correlation between higher BMI and SDB, and that correlation was more apparent in females with high BMI. We found nocturnal hypoxia in 86.97% cases, and 74.36% of them had airway disease. Snoring with RDI ≤ 5 / hr was observed in 102 patients. Of them 83 (81.37%) subjects had simple snoring and 19 (18.63%) subjects had excessive snoring with multiple sleep fragmentation but RDI ≤ 5 that might be highly suggestive of upper airway resistance.
syndrome (URS). we could not confirm the diagnosis of URS, as we did not measure the intra-thoracic pressure by placing catheter inside esophagus. All such cases were referred to ENT specialist for further evaluation.

We found abnormal RDI in 84.58% cases, and 61.62% cases had more than 20 RDI per hour of sleep. OSA was diagnosed by EDS clinically and abnormal RDI in PSG. As all patients with abnormal RDI had EDS, we estimated that 84.06% males, 87.10% females and 84.59% of our study population had OSA. We performed split-night sleep study in 362 cases, and of them 15.47% cases could not tolerate CPAP. Though gradual daytime trials, selecting right mask and using humidification might have decrease noncompliance and increase tolerability of CPAP, in our laboratory we did not perform gradual daytime trials and use humidification routinely. In split-night PSG we perform first and one time titration of CPAP, not serial titration. In 69 (19.06%) subjects we could not successfully titrate CPAP. Inadequate correction of hypoxemia due to co-morbid condition like COPD, asthma, obesity and hypothyroidism was the main factor (49.28%) responsible for failure in our study. Other causes included inadequate CPAP titration time in 18.84% cases; predominance of central sleep apnea in 10.14% cases; mask leak, even after change of mask, in 13.04% cases and PLMS in 8.7% cases. In remaining 247 (68.23%) cases CPAP was found to be effective at the first attempt, and minimum effective pressure was 10 cm of H₂O or less in more than half of the cases (62.42%).

This report does not include the follow up, which is subject of another ongoing study. All these data reflect that patients are referred for or come for PSG late. Though there is a distinct increase in awareness among physicians about sleep disordered breathing in the last few years, we stress for more referral and subjective evaluation by polysomnography.

References


Sanjay Gandhi Postgraduate Institute of Medical Sciences
Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow will be organizing two NIH-supported workshops on
‘Workshop on Scientific Writing’ (Goa, September 11-15, 2010)
and
‘Introduction to Clinical Trials and Good Clinical Practices’ (Trivandrum, December 3-5, 2010).
Travel Support may be available. Those interested in further details, may please visit http://www.biomedresearch.in or Contact : Dr. Rakesh Aggarwal, Department of Gastroenterology, SGPGI, Lucknow at sgpgi.courses@gmail.com