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Original Article

Internal Medicine Section

Correlation between Degree of Desaturation and Severity of Obstructive Sleep Apnoea: A Cross-sectional Study

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ABSTRACT

Introduction: Obstructive Sleep Apnoea (OSA) is major Non Communicable Disease (NCD) which is becoming very common worldwide. The OSA results in day time hypersomnolence, nocturnal hypoxia and snoring. Repeated desaturation events during sleep results in aerobic metabolism at tissue level changing to anaerobic metabolism, which results in cellular inflammation and insulin resistance further complicating metabolic syndrome.

Aim: To study correlation between degree of desaturation and severity of obstructive sleep apnoea.

Materials and Methods: This cross-sectional study was conducted in Department of Pulmonary medicine at KS Hegde Medical Academy (tertiary care hospital), Mangaluru, Karnataka, India, from March 2018 to February 2021. Total 54 patients who underwent overnight polysomnography and diagnosed to have OSA were included in the study. The minimum recorded oxygen saturation (SpO_2) defined as maximum desaturation was noted. Relative desaturation was defined as drop in saturation by 3% or more from the pre-event baseline. Correlation between total number of relative desaturation and Apnoea Hypopnea Index (AHI) was analysed. The correlation between two variables were analysed by Pearson's correlation and the coefficient was calculated. The p-value was calculated by regression analysis and Analysis of Variance (ANOVA).

Results: Total of 54 patients was included in the study. Out of which, 22 were mild, 14 moderate and 18 severe OSA, respectively. Number of relative desaturations recorded was from 0-636. The correlation between AHI and mean SpO_2 in sleep was r-value=-0.4542 (p-value=0.001) and the correlation between AHI and minimum SpO_2 was r-value=-0.45577 (p-value=0.001), respectively. Correlation between mean SpO_2 and minimum SpO_2 was r-value=0.747266 (p-value <0.001) and the correlation between AHI and relative desaturation was r-value=0.876698 (p-value=0.001).

Conclusion: As the severity of the obstructive sleep apnoea worsened, there was greater degree of desaturation in sleep and the lowest SpO_2 was also observed during severe obstructive sleep apnoea.

Keywords: Anaerobic metabolism, Hypoxia, Relative desaturation

INTRODUCTION

Obstructive Sleep Apnoea (OSA) is the most common type of sleep related breathing disorder characterised by repetitive episodes of upper airway obstruction leading to desaturations, arousals, variations in heart rate, daytime sleepiness and impaired quality of life during daytime. OSA is diagnosed typically after overnight polysomnographic test showing events of apnoea (complete or more than 90% cessation of oronasal airflow for more than or equal to 10 seconds) and hypopnoea (more than 30% reduction in oronasal airflow lasting for more than or equal to 10 seconds with >3% fall in SpO_2 from the pre-event baseline and/or arousal) of more than per hour of sleep with symptoms suggestive of OSA [1]. There are various systems used to classify the severity of OSA. The worldwide accepted system being American Academy of Sleep Medicine (AASM) Apnoea Hypopnea Index (AHI), where AHI of 5-15 events per hour is mild, 15-30 events/hour is moderate and more than 30 events per hour is severe OSA [2].

The disruptions to breathing have lead to repeated blood gas disturbances (hypercapnia and hypoxaemia) and sympathetic nervous system activation [3]. Repeated desaturation events might result in aerobic metabolism at tissue level changing to anaerobic metabolism, which results in cellular inflammation and insulin resistance further complicating metabolic syndrome [4]. Previous study has been conducted on SpO_2 less than 90% and respiratory arousal indices [5]. However severity of OSA and its relation to degree of desaturation were not compared previously. Hence, to address this lacuna it was hypothesised that more severe the OSA, more severe the desaturation and this research was conducted to study degree of desaturation and severity of OSA to understand the metabolic implications of hypoxia.

MATERIALS AND METHODS

A cross-sectional study was conducted in Department of Pulmonary Medicine at KS Hegde Medical Academy (tertiary care hospita), Mangaluru, Karnataka, India from March 2018 to February 2021. The ethical clearance was obtained from the Institutional Ethical Committee (NU/CEC/2018/0201).

Sample size calculation: The sample size was calculated using Cochran formula:

$$N=\frac{Z^2pq}{e^2}=53.16$$

Where, n=sample size,

Z=standard normal deviate {1.96 (taking a confidence interval of 95%)}

p=proportion in the target population having OSA {0.036 (taking 3.6% of population having OSA)} [6]

q=proportion in the target population not having OSA {1-p=0.964}

e=degree of accuracy required (0.05)

Inclusion and Exclusion criteria: All consenting 54 patients who underwent overnight polysomnography and diagnosed to have OSA by the pulmonologists were included in the study. Subjects diagnosed to have central sleep apnoea and not consenting for the study were excluded from the study.

Study Procedure

- Demographic details like age, sex, height, weight and BMI were taken.

- Sleep study data included
  -Apnoea Hypopnoea Index (AHI),
  -Number of relative desaturations,
  -Mean SpO_2 recorded in sleep,
  -Minimum SpO_2 recorded in sleep

These parameters are part of the routine sleep study which were recorded in polysomnography laboratory {Alice-5 (Philips Respironics)} and retrieved from the software system. AHI is the current method for severity grading of OSA, which includes number of apnoea and hypopnea per hour of sleep. AHI severity grading OSA is divided [7]:

- Mild OSA: AHI of 5-15
- Moderate OSA: AHI >15 upto 30
- Severe OSA: AHI>30

The AHI below 5 per hour was considered as normal and not included in the study. The minimum recorded SpO_2 defined as maximum desaturation was noted. Relative desaturation was defined as drop in saturation by 3% or more from the pre-event baseline [1].

STATISTICAL ANALYSIS

Statistical analysis was done using the software Statistical Package for Social Sciences (SPSS) version 2.0. Correlation between total number of relative desaturation and AHI was analysed. Nominal data were analysed as frequency and percentages. The correlation between two variables were analysed by Pearson's correlation and the coefficient was calculated. The p-value was calculated by regression analysis and Analysis of Variance (ANOVA).

RESULTS

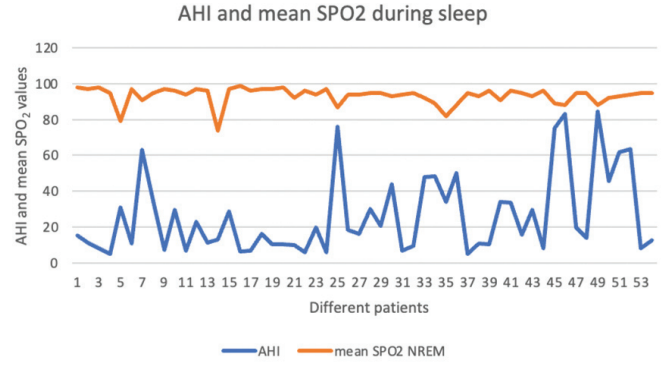
Out of total 54 patients, 70.37% were males. Majority of them were between the age group 45-57 years followed by 18-31 years. Total 18 patients had a BMI between 26-31.4 kg/m^2 followed by 15 patients between 20.5-25.9 kg/m^2. One patient was paraplegic and hence BMI could not be assessed. Out of the total, 22 had mild, 14 moderate and 18 severe OSA, respectively [Table/Fig-1]. Number of relative desaturations recorded was from 0-640 [Table/Fig-2]. Among desaturation details of all the patients, the minimum saturation (SpO_2) recorded during sleep ranged from 27-97% [Table/Fig-3] and mean SpO2 ranged between 74-99% [Table/Fig-4].

Demographic details	Frequency	Percentage
Age (years)		
18-31	17	31.48%
32-44	12	22.22%
45-57	19	35.18%
58-70	6	11.11%
Gender		
Males	38	70.37%
Females	16	29.62%
Body mass index (kg/m^2)*		
14.9-20.4	9	16.66%
20.5-25.9	15	27.77%
26-31.4	18	33.33%
31.5-36.9	10	18.51%
37-42.4	1	1.85%
Obstuctive sleep apnoea severity as per Apnoea Hypopnea Index (AHI)		
Mild (5-15)	22	40.74%
Moderate (15.1-30)	14	25.92%
Severe (>30)	18	33.33%

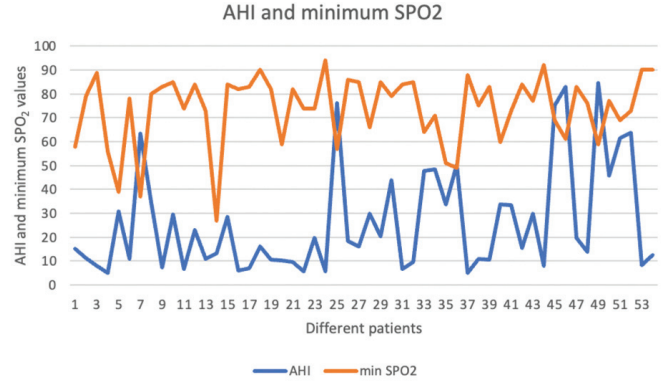
[Table/Fig-1]: Demographic details.
*One patient was paraplegic so; BMI could not be calculated

Parameters	Number of patients	Percentage
Mean SpO_2		
74-78.4	1	1.85%
78.5-82.8	2	3.7%
82.9-87.2	1	1.85%
87.3-91.6	7	12.96%
91.7-96	31	57.4%
96.1-100	12	22.22%
Minimum SpO_2		
27-41	3	5.55%
41.1-55	2	3.7%
55.1-69	11	20.37%
69.1-83	22	40.74%
83.1-97	16	29.62%
Relative desaturation		
0-160	34	62.96%
161-320	10	18.51%
321-480	6	11.11%
481-640	4	7.4%

[Table/Fig-2]: Details of desaturations in sleep of the patients included for the study.

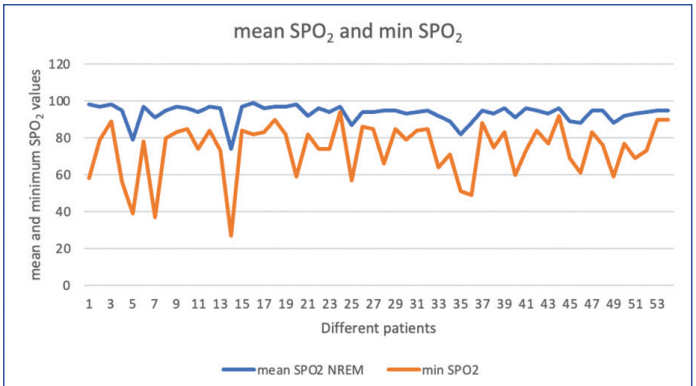


[Table/Fig-3]: Relationship between Apnoea Hypopnea Index (AHI) and mean saturation in sleep.
The correlation coefficient between AHI and mean SpO_2 in sleep was-0.4542 which was moderate correlation and the correlation is negative which means as the AHI increases, the desaturation was more (recorded SpO_2 was lower)

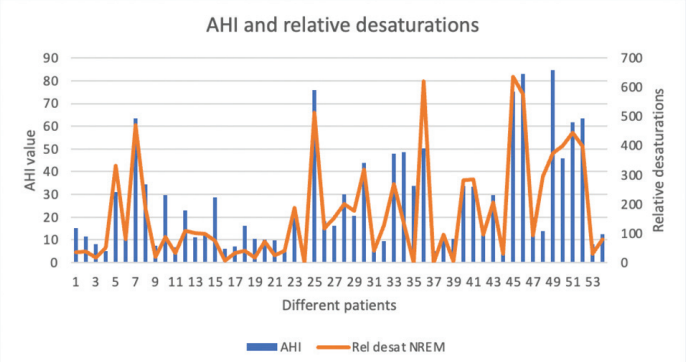


[Table/Fig-4]: Relationship between Apnoea hypopnea index (AHI) and minimum saturation in sleep.
The correlation between AHI and minimum SpO_2 was -0.45577 which was moderate correlation and the correlation was negative which means as the AHI increases, the desaturation was more (recorded SpO_2 was lower)

The correlation between AHI and mean SpO_2 in sleep was r-value=-0.4542, p-value=0.001 and the correlation between AHI and minimum SpO_2 was r-value=-0.45577, p-value=0.001, respectively. Correlation between mean SpO_2 and minimum SpO_2 was r-value=0.747266, p-value <0.001 and the correlation between AHI and relative desaturation was r-value=0.876698, p-value=0.001 [Table/Fig-3-6].



[Table/Fig-5]: Relationship between mean and minimun saturation in sleep.
Correlation between mean SpO_2 and minimum SpO_2 was 0.747266 which means strong correlation



[Table/Fig-6]: Relationship between AHI and relative desaturations in sleep.
Correlation between AHI and relative desaturation was 0.876698 which means strong correlation

DISCUSSION

This study showed that OSA is more prevalent in males than females and a male to female ratio was 2.3:1 which is similar to previous studies showing a ratio of 3:1 to 5:1 in the general population [8-10]. OSA is commonly seen in the age group between 44-57 years and is consistent with previous study which was common in 45-53 years [8].

Minimum SpO_2 ranged from 27-94% in various subjects with OSA in our study. Minimum SpO_2 and severity of OSA (as determined by AHI) had only moderate correlation (r of -0.45), mean SpO_2 and AHI also had moderate correlation (r of -0.45), relative desaturation and AHI had a strong correlation (r-value=0.87) which is consistent with previous study, in which Wali SO et al., found that parameters such as Desaturation Index (DI), the sum of all desaturations, desaturation below 90%, the average duration of respiratory events, and indices of total arousals and respiratory arousals correlated directly with severity OSA (p-value <0.001). The correlation between mean SpO_2 and minimum SpO_2 in sleep was 0.75. This means that nocturnal hypoxia and the nadir saturation in sleep are linked [5].

The type of metabolism at cellular level is determined by the oxygen concentration in the mitochondria [11-14]. This is because the final step for aerobic metabolism takes place in the mitochondria. Cellular metabolic demands, the cell type and its adaptability to hypoxia are the factors which determine the response to various levels of hypoxia from substantial adaptation to cell death [14-16]. If tissue hypoxia occurs, global compensatory respiratory and cardiac mechanisms like regional pulmonary vasoconstriction to improve ventilation perfusion ($\dot{V}/\dot{Q}$) matching, hyperventilation to improve alveolar oxygen tension, acidosis-related right shift of the oxyhaemoglobin dissociation curve and increase in cardiac output occur to improve oxygen delivery are activated [13-16].

Hypoxia Inducible Factors (HIFs) are a group of heterodimeric proteins that interact with hundreds of genes in response to hypoxia [13-19]. It plays a central role in adaptive tissue responses like up-regulation of erythropoietin, angiogenic factors, and vasoactive mediators; activation of glycolytic enzymes to produce anaerobic metabolism (with resulting lactate production); and even a mitochondrial hibernation-like phenomenon resulting in decreased oxygen demands [8,18-28].

Mean SpO_2<92% and minimum SpO_2<80% in sleep were associated with carotid plaque formation regardless of their normotensive or hypertensive status [29,30]. Ventricular ectopic in OSA patients is more likely if SpO_2 drops below 60% and unlikely if SpO_2 stays above 60% [30]. It was also observed symptoms of OSA were closely related to oxygen desaturations than AHI [31]. Similarly resistance to ischaemic conduction failure is a sensitive but non specific marker of nocturnal hypoxemia in OSA patients [32]. Repeated hypoxia and normoxia induces endothelial dysfunction [33]. Oxygen desaturation plays a key role in the connection between obstructive sleep apnea and hypercoagulability state [34]. Nocturnal hypoxia due to OSA is an independent predictor of atrial fibrillation in patients with subacute ischaemic stroke [35]. In this study it has been observed as severity of the OSA worsens there is steeper fall of saturation which leads pronounced physiological impact of apnoea.

Limitation(s)

Study involved sample size of 54 which was smaller to conclude physiological impacts of apnoea and hypopnea. Study should have also incorporated heart rate variations as other physiological variant to assess severity of OSA.

CONCLUSION(S)

Degree of desaturation worsened with increasing severity of OSA. Greater degree of desaturation and lowest recorded saturation was seen during severe obstructive sleep apnoea. Further studies are required to confirm that desaturation is a surrogate indicator of severity of obstructive sleep apnoea.

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