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Original Research Paper

Respiratory Medicine

"STUDY OF PULSE OXIMETRY CHANGES DURING SLEEP IN PATIENTS OF CHRONIC RESPIRATORY DISEASES"

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ABSTRACT Hypoxemia results in a poor clinical outcome, making pulse oximetry an important tool to monitor patient oxygenation routinely both in primary care and in hospital. Overnight pulse oximetry (OPO) also has emerged as one of the most widely used techniques to determine the Respiratory status and oxygen saturation status, as it provides adequate information about patient's oxygenation. Overnight pulse oximetry alone is often used and also a good screening tool in the primary care setting. It can be used as a primary screening tool in detecting Obstructive Sleep Apnoea. It aides in the Management of Chronic Obstructive Pulmonary Disease and Interstitial Lung Diseases.

KEYWORDS : Overnight pulse oximetry (OPO), Apnoea, Polysomnography (PSG), Photoplethysmography (PPG), Pulmonary disease (COPD)

INTRODUCTION

Hypoxemia results in a poor clinical outcome, making pulse oximetry an important tool to monitor patient oxygenation routinely both in primary care and in hospital. (1)

Pulse oximetry is a spectrophotometry technology which determines the arterial oxygen saturation by the detection of pulsatile blood flow and is based on differing absorption spectra of oxyhaemoglobin and deoxyhaemoglobin which includes the red and near-infrared wavelengths of light.(2)

The oxyhaemoglobin absorbs near-infrared light and dissipates the red component of light which makes it appear bright red. On the contrary, deoxyhaemoglobin absorbs the red component of light more and scatters the near infrared, making it look less red.(3)

During a routine OPO, one can get an idea about the mean overnight saturation (mean SaO2) and lowest SaO2 during the entire night recording. In general healthy controls, the normal overnight mean oxygen saturation is 96%.(4)

OPO has been used extensively in the field of sleep medicine and classified as a type 4 monitoring device. (5)

One can also report on the number of oxygen desaturations (decrease of oxygen saturation by 4% from the baseline per hour of recording) as an index, generally called oxygen desaturation index (ODI).(6)

Although polysomnography (PSG) is the gold standard for studying the sleep quality and diagnosing SDB, it is expensive, time consuming, labor intensive, less readily available, and requires regular monitoring and expertise for the interpretation. On the other hand, OPO can be used as a quick and valuable screening tool.(7,8)

It can be used as a case-selection technique to detect patients who need PSG.(9)

Nocturnal pulse oximetry is a low-cost, safe, simple, convenient, non-invasive, and effective screening method for SDB in adults. (10)

Apnea and hypopnea cause an arousal from sleep causing sympathetic activation, sleep disruption, snoring, fatigue, nocturia, morning headaches, and 8 excessive daytime sleepiness. SDB leads to increased risk of motor-vehicle crashes.(11,12)

Several studies have shown that sleep apnea is associated with hypertension, stroke, heartfailure, obesity, metabolicsyndrome, (13)diabetes, (14)neurocognitive deficits, (15) gastroesophageal reflux disease, (16) and erectile dysfunction.(17)

Others have also reported that in a population at high risk for OSA, OPO can be an effective screening tool.(18)

Romem et al. evaluated the accuracy of photoplethysmo graphy (PPG)- based finger pulse oximeter in the diagnosis of OSA. The study was performed on 73 patients with a likely diagnosis of OSA using the PPGbased device and simultaneous in-laboratory PSG. It was concluded that the pulse oximetry data were compared well with the PSG data.(19)

Morbid obesity (BMI >40 kg/m2) leads to a decreased basal nocturnal saturation due to the supine 9 hypoventilation, hypoxemia, and hypercapnia during sleep secondary to a large abdomen, reduced diaphragmatic excursions, and low chest wall compliance.(20)

Several possible reasons can be put forward to explain these variations.(21)

As reported by Böhning et al., there is an interdevice variability between different pulse oximeters which may affect the quality of data and hence the study results.(22)

In addition, there is variability in how physicians interpret oximetry tracings and appears to be another limiting step towards its wider use.(23)

It is also important to point however that oximetry testing cannot distinguish between OSA and central sleep apnea, so it is insufficient for the definitive diagnosis of OSA or qualify patients for therapy.(24)

Role Of Overnight Pulse Oximetry In The Management Of Chronic Obstructive Pulmonary Disease

OSA and hypoxemia are commonly encountered in chronic obstructive pulmonary disease (COPD) patients.(25)

The sleep-related respiratory changes can prove to be

dangerous in a patient of COPD due to the reduced diaphragmatic excursion, ventilation-perfusion mismatch, and decreased chest wall compliance.(26)

Nocturnal hypoxemia can lead to cardiovascular complications and secondary pulmonary hypertension.(27)

The presence of nocturnal hypoxemia can easily be assessed with home OPO which allows one to measure the T-90 value, which is the time at night spent below 90% oxygen saturation.(28]

The overlap of COPD with OSA makes the diagnosis and prognosis very challenging.[29]

It leads to poor sleep and lower quality of life with increased morbidity and mortality. About 5–10% of COPD patients have OSA, which is about 0.5–1% of the general population ≥40 years.[30]

Patients with OSA and hypoxemic COPD 11 receiving long term oxygen therapy (LTOT) have higher survival rates when treated with CPAP, as compared with those treated with LTOT only.[31]

Role Of Overnight Pulse Oximetry In The Management Of Neuromuscular Disorders

Neuromuscular respiratory failure in disorders such as amyotrophic lateral sclerosis (ALS) and muscular dystrophies is characterized by daytime hypercapnia, dyspnoea, and nocturnal hypoventilation (NH).[32]

This NH is an indication for non-invasive ventilation (NIV).[33] Hence, early detection of hypercapnia and NH is important so that NIV can be timely initiated which would improve the quality of life in patients of ALS.[34]

NH is detected by lung function testing, PSG, or by exhaled PCO2 monitoring.[35]

Many patients can be hypoxemic and symptomatic at a higher FVC. Hence, nocturnal oximetry helps to identify these patients for earlier respiratory intervention.[36]

Nocturnal pulse oximetry indirectly provides information about the arterial saturation in the night time and indirectly provides information about the respiratory status..[37]

Although OPO is not a substitute for PSG, the low cost and convenience of this technique has stimulated its application in ALS.[38]

A mean nocturnal O2 saturation below 93% as detected by OPO is of prognostic value in ALS.[39]

The data obtained from nocturnal home pulse oximetry and used in decision-making are the duration of the time with oxygen saturation SaO2 (40)

MATERIALS AND METHODS

Place Of Study: Department of Pulmonary Medicine, MNR Medical College & Hospital, Sanga Reddy

Sample Size: 100 patients.

Sampling Technique: Convenient Sampling

Study Type: Cross sectional study

Study Period: 18 months (November, 2022 to March, 2024)

Methodology:

- A written informed consent was taken from all patients before their inclusion in the study. The study was approved by the ethical committee of the hospital. All the patients were interviewed for detailed clinical history and examined. The pros and cons of both the procedure were explained in detail to the patient.
- Data was collected using a case recording proforma pertaining to patient particulars- age/sex, history, clinical examination, investigations, diagnosis, medical management, after admission in the Department of Pulmonology.

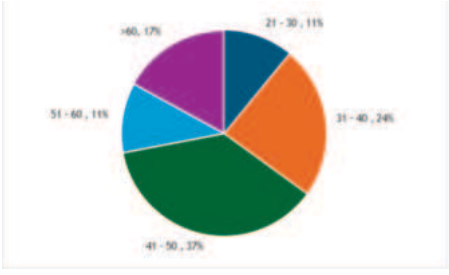
- **Investigations Which Were Carried Out:**
- Routine Blood Tests
- Chest Radiography
- Pulmonary Function Test
- ABG
- ECG
- 2D Echo

RESULTS

Table 1: Distribution Based On Age

	Frequency	Percentage
21 – 30	11	11%
31 – 40	24	24%
41 – 50	37	37%
51 – 60	11	11%
>60	17	17%
Total	100	100%

This table presents the distribution of the study participants based on their age groups. It shows the number and percentage of participants within specific age ranges. The age group of 41-50 years has the highest representation, comprising 37% of the total participants, while both the 21-30 and 51-60 age groups each account for 11%. The age group over 60 years represents 17% of the participants. The total number of participants is 100, making the percentages directly reflective of the actual participant numbers.

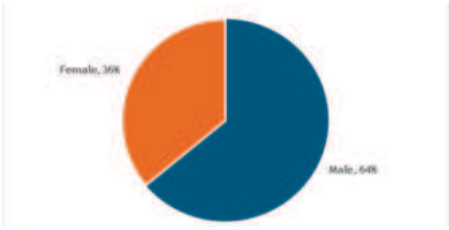


Graph 1: Pie chart showing Age distribution.

Table 2: Distribution Based On Gender

	Frequency	Percentage
Male	64	64%
Female	36	36%
Total	100	100%

This table displays the gender distribution among the study participants. It shows that 64% of the participants are male, and 36% are female. The total number of participants is 100, ensuring that the percentages align directly with the participant count.

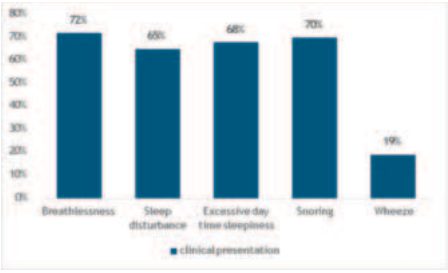


Graph 2: Pie chart showing Sex distribution.

Table 3: Distribution Based On Clinical Presentation

	Frequency	Percentage
Breathlessness	72	72%
Sleep disturbance	65	65%
Excessive day time sleepiness	68	68%
Snoring	70	70%
Wheeze	19	19%

This table outlines the distribution of clinical symptoms presented by the participants. The most common symptoms include breathlessness (72%), excessive daytime sleepiness (68%), and snoring (70%). Sleep disturbance is reported by 65% of the participants, while wheeze is the least common symptom, affecting 19% of theparticipants. The percentages are calculated based on the total number of participants.

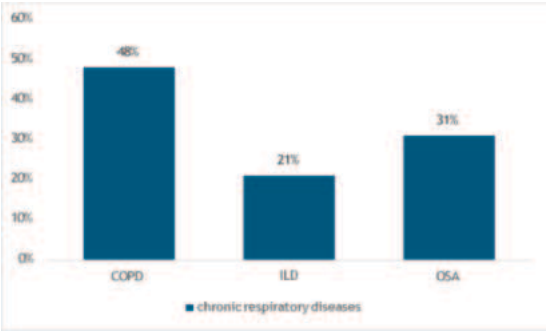


Graph 3: Bar graph showing Clinical presentation.

Table 4: Distribution Based On Chronic Respiratory Diseases

	Frequency	Percentage
COPD	48	48%
ILD	21	21%
OSA	31	31%

This table categorizes participants based on the presence of chronic respiratory diseases. Chronic Obstructive Pulmonary Disease (COPD) is the most prevalent, affecting 48% of the participants. Obstructive Sleep Apnea (OSA) affects 31% of the participants, and Interstitial Lung Diseases (ILD) is present in 21% of the participants. These percentages are derived from the total number of participants.

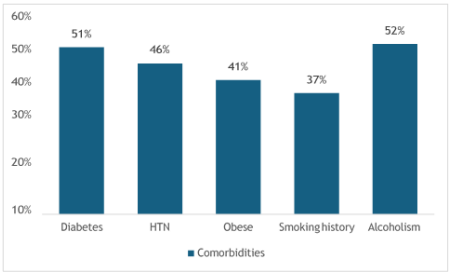


Graph 4: Bar graph showing chronic respiratory diseases.

Table 5: Distribution Based On Comorbidities

	Frequency	Percentage
Diabetes	51	51%
HTN	46	46%
Obese	41	41%
Smoking history	37	37%
Alcoholism	52	52%

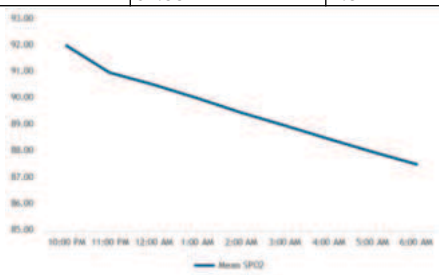
This table details the distribution of various comorbidities among the participants. Alcoholism is the most common comorbidity, present in 52% of the participants, followed by diabetes (51%), and hypertension (HTN) (46%). Obesity and smoking history are present in 41% and 37% of the participants, respectively. The percentages indicate the proportion of participants with each comorbidity.



Graph 5: Bar graph showing Comorbidities

Table 6: Overnight SPO2 Values

	Mean	SD
10 PM	92.05	1.56
11 PM	91.01	1.62
12 AM	90.55	1.70
1 AM	90.04	1.72
2 AM	89.49	1.84
3 AM	89	1.92
4 AM	88.49	1.89
5 AM	88	1.93
6 AM	87.53	1.94



Graph 6: Graph showing Mean SPO2 Values

This table provides a detailed account of the mean SPO2 (oxygen saturation) levels of participants across different times during the night, from 10 PM to 6 AM. Oxygen saturation is a crucial measure of how well oxygen is being carried to the tissues and organs, reflecting the participants' respiratory function during sleep.

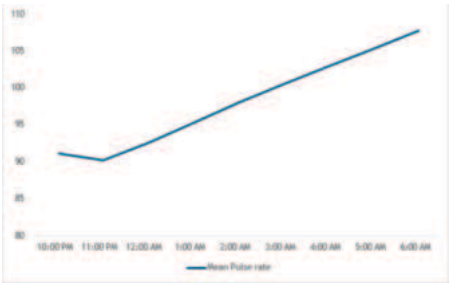
- 10 PM: The mean SPO2 level at 10 PM is 92.05 with a standard deviation (SD) of 1.56. This indicates that the participants generally have a good oxygen saturation level at the beginning of the night.
- 11 PM: By 11 PM, the mean SPO2 level drops slightly to 91.01 with an SD of 1.62. The decrease in mean SPO2 indicates the beginning of a gradual reduction in oxygen levels as the participants enter deeper sleep stages.
- 12 AM: At midnight, the mean SPO2 further declines to 90.55 with an SD of 1.70, showing a continuing trend of decreased oxygen saturation.
- 1 AM: The mean SPO2 level at 1 AM is 90.04 with an SD of 1.72. This point marks the first instance where the mean SPO2 level falls below 90, indicating that some participants might be experiencing significant desaturation events.
- 2 AM: The mean SPO2 level at 2 AM drops to 89.49 with an SD of 1.84, showing further decline in oxygen saturation.
- 3 AM: By 3 AM, the mean SPO2 level is 89.00 with an SD of 1.92, continuing the downward trend.
- 4 AM: At 4 AM, the mean SPO2 level is 88.49 with an SD of 1.89. This time point shows a slight stabilization in the rate of decline.
- 5 AM: The mean SPO2 level at 5 AM is 88.00 with an SD of 1.93, indicating a relatively stable but low oxygen saturation level.
- 6 AM: At 6 AM, the mean SPO2 level reaches its lowest point at 87.53 with an SD of 1.94. This suggests that the

participants' oxygen levels are at their lowest towards the end of the sleep cycle, possibly due to prolonged periods of deep sleep or REM sleep.

Overall, this table illustrates a consistent decrease in mean SPO2 levels throughout the night, with standard deviations indicating moderate variability among participants. This downward trend might be indicative of sleep-related breathing disorders or normal physiological changes during sleep.

Table 7: Overnight Pulse rate values

	Mean	SD
10 PM	91.55	5.57
11 PM	90.62	6.43
12 AM	92.97	6.48
1 AM	95.68	6.44
2 AM	98.42	6.63
3 AM	100.92	7.06
4 AM	103.33	7.43
5 AM	105.71	7.68
6 AM	108.16	7.96



Graph 7: Graph showing Mean Pulse rate

This table presents the mean pulse rate of participants at hourly intervals during the night, from 10 PM to 6 AM, along with the standard deviations, reflecting cardiovascular function during sleep.

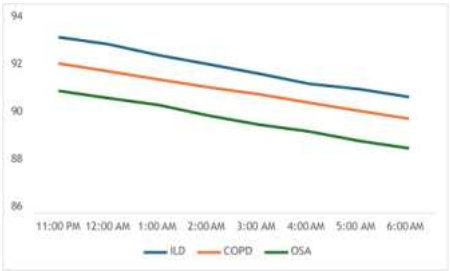
- 10 PM: The mean pulse rate at 10 PM is 91.55 beats per minute (bpm) with a standard deviation (SD) of 5.57. This baseline measurement indicates the participants' heart rate before significant sleep stages have commenced.
- 11 PM: By 11 PM, the mean pulse rate slightly decreases to 90.62 bpm with an SD of 6.43, suggesting the onset of relaxation and the beginning of the sleep process.
- 12 AM: At midnight, the mean pulse rate increases to 92.97 bpm with an SD of 6.48. This increase could be associated with the transition to deeper stages of sleep.
- 1 AM: The mean pulse rate rises further to 95.68 bpm at 1 AM with an SD of 6.44, indicating increased autonomic activity, possibly during REM sleep.
- 2 AM: By 2 AM, the mean pulse rate continues to rise to 98.42 bpm with an SD of 6.63. This period may correspond to more frequent REM cycles.
- 3 AM: At 3 AM, the mean pulse rate reaches 100.92 bpm with an SD of 7.06, reflecting a peak in cardiovascular activity during the night.
- 4 AM: The mean pulse rate at 4 AM is 103.33 bpm with an SD of 7.43, continuing the upward trend and possibly indicating intense REM sleep periods.
- 5 AM: By 5 AM, the mean pulse rate further increases to 105.71 bpm with an SD of 7.68. This could be associated with the body's preparation for waking.6 AM: At 6 AM, the mean pulse rate reaches its highest value at 108.16 bpm with an SD of 7.96. This significant increase suggests the participants are nearing the end of their sleep cycle, and the body is gearing up for morning activities.

The table shows a clear upward trend in the mean pulse rate throughout the night, with increasing standard deviations indicating greater variability in heart rates among participants.

Table 8: SPO2 And Respiratory Diseases

	ILD		COPD		OSA		P
	Mean	SD	Mean	SD	Mean	SD	value
11:00 PM	92.81	0.87	91.19	0.89	89.52	1.50	0.001*
12:00 AM	92.38	0.97	90.71	1.07	89.07	1.55	0.001*
1:00 AM	91.71	0.96	90.21	1.20	88.65	1.68	0.001*
2:00 AM	91.14	1.15	89.73	1.38	88.00	1.73	0.001*
3:00 AM	90.57	1.12	89.31	1.56	87.45	1.79	0.001*
4:00 AM	89.95	1.20	88.79	1.60	87.03	1.72	0.001*
5:00 AM	89.62	1.32	88.29	1.62	86.45	1.61	0.001*
6:00 AM	89.14	1.46	87.81	1.62	86.00	1.57	0.001*

ANOVA test; * = Statistically significant

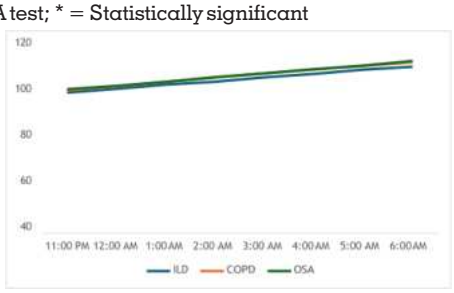


Graph 8: Graph showing SPO2 values and respiratory diseases

Table 9: Pulse Rate And Respiratory Diseases

	ILD		COPD		OSA		P value
	Mean	SD	Mean	SD	Mean	SD	
11:00 PM	89.24	6.83	90.67	6.60	91.48	5.92	0.46
12:00 AM	91.62	7.26	93.21	6.60	93.52	5.80	0.55
1:00 AM	94.33	7.23	95.96	6.45	96.16	5.94	0.55
2:00 AM	96.14	7.12	99.06	6.48	98.97	6.38	0.20
3:00 AM	98.95	7.68	101.40	6.99	101.5	6.71	0.35
4:00 AM	101.10	8.27	103.81	7.58	104.1	6.50	0.30
5:00 AM	103.81	8.05	106.08	8.06	106.4	6.82	0.44
6:00 AM	105.67	7.91	108.52	8.47	109.2	7.01	0.25

ANOVA test; * = Statistically significant



Graph 9: Graph showing Pulse rate and respiratory diseases

Table 10: Percentage Needed Polysomnography

	Frequency	Percentage
Yes	12	30%
No	28	70%
Total	40	100%

Table 11: Percentage needed Oxygen therapy

	Frequency	Percentage
Yes	24	60%
No	16	40%
Total	40	100%

Table 12: Interstitial Lung Diseases patients needing Oxygen supplementation

	Frequency	Percentage
Yes	4	10%

No	36	90%
Total	40	100%

DISCUSSION

Age distribution

Our study presents the distribution of participants based on age groups, showing a diverse age range among the 100 participants. The highest representation is in the 41-50 age group (37%), followed by the 31-40 age group (24%). The 21-30 and 51-60 age groups each account for 11%, while participants over 60 years constitute 17%. This distribution provides a snapshot of the age demographics in our sample.

Chiang et al on the use of overnight pulse oximetry for screening OSA in a primary care setting also presented demographic data, noting that the mean age of participants was 52 years, with a substantial portion of participants aged between 50 and 60 years . Our study's highest representation in the 41-50 age group aligns with the reference study's findings, indicating that middle-aged individuals are a significant demographic for OSA screening. This similarity underscores the importance of targeting middle-aged populations for sleep-disordered breathing evaluations, given their higher prevalence rates.(41)

In the study by Dumitache-Rujinski et al, the mean age of participants in the morbidly obese group was 59.4 years, while the non-obese group had a mean age of 51.2 years . These findings suggest that older adults, particularly those over 50, are more frequently diagnosed with OSA, which is consistent with our finding that 54% of our participants are over 40 years old. The age distribution in our study supports the reference study's emphasis on the prevalence of sleep apnea in older adults,highlighting the need for targeted screening in this age group to manage OSA effectively.(42)

Singh et al. discussed the demographics of patients undergoing overnight pulse oximetry, noting that older adults are more likely to experience sleep-disordered breathing due to age-related physiological changes . Our study's age distribution, with a significant proportion of participants over 40 years, aligns with this observation. The reference study underscores the increased risk of sleep apnea with advancing age, which is reflected in our data showing higher percentages of older adults.

The age distribution in our study reveals a significant representation of middle- aged and older adults, with the highest concentration in the 41-50 age group. This demographic pattern is consistent with findings from the reference studies, which highlight the prevalence of sleep-disordered breathing, particularly OSA, among older adults.

CONCLUSION

The findings of this study highlight the significant prevalence of sleep-disordered breathing and associated conditions in the study population. The consistent decline in SPO2 levels and the steady increase in pulse rates during the night suggest the presence of conditions like OSA, COPD and ILD with Respiratory Failure which require early detection and management.

Overall, this study reinforces the importance of comprehensive screening and management of sleep-disordered breathing and associated conditions requiring Oxygen Therapy. The use of overnight pulse oximetry and continuous physiological monitoring are effective tools for identifying at-risk individuals and ensuring timely intervention to improve health outcomes. The alignment of our findings with established research underscores the reliability of these methods in clinical practice, highlighting their critical role in managing respiratory health.

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