Zagazig University Medical Journal
www.zumj.journals.ekb.eg
https://doi.org/10.21608/zumj.2024.310483.3511 Volume 30, Issue 9, December. 2024
Manuscript id: ZUMJ-2408-3511
Doi: 10.21608/ZUMJ.2024.310483.3511

ORIGINAL ARTICLE

Polysomnographic Parameters and Assessment of Cardiovascular Complications in Patients with Sleep Disordered Breathing

Adel Hassan Ghoneim[1], Nagwan Adel Ismail[1], Mona Hassan Mahmoud[1], Walid I. M. Elgendy[1]*
[1] Chest Department Faculty of Medicine, Zagazig University, Zagazig, Egypt

***Corresponding author**: Walid I. M. Elgendy

Email: walidim2000@yahoo.com

Submit Date: 18-08-2024
Revise Date: 02-09-2024
Accept Date: 22-09-2024

ABSTRACT

Background: Sleep-disordered breathing (SDB) is a significant public health concern, including obstructive sleep apnea (OSA) and central sleep apnea. SDB, even in milder forms, stresses the cardiovascular system, leading to complications . While the apnea/hypopnea index (AHI) has traditionally assessed SDB severity, recent research highlights its limitations, emphasizing the need for additional polysomnographic parameters for a comprehensive cardiovascular risk assessment in patients with Sleep Disorders Breathing.

Methods: This retrospective study was carried out at the Sleep Disorders Breathing unit, at Zagazig University Hospitals. The study involved 109 participants with cardiac illness and 109 participants without cardiac illness The specialized setting was utilized to investigate polysomnographic parameters and cardiovascular problems in patients with SDB.

Results: The primary results of this study revealed that the cardiac group exhibits a lower prevalence of pure OSA (57.9 % vs. 86.1 % in the non-cardiac group) but a higher prevalence of mixed sleep apnea (39.5% vs. 13.9% in the non-cardiac-group-)-with high statistical significance (P value > ٠,٠٠١) . Oxygen Desaturation Index, Time of sleep below 90% (T<90%), Arrhythmia Index, and Arousal Index are significantly higher in the cardiac group (P value <.001) but Diastolic Dipping of blood pressure is significantly lower in the same group (P value 0 <.001).

Conclusions: Polysomnographic parameters other than AHI, such as Oxygen Desaturation Index, Time of sleep less than 90% (T<90%), Arrhythmia Index, Arousal Index, and Diastolic Dipping of blood pressure emerge as a key marker of heightened risk of cardiovascular complications.

Keywords: Sleep disorders breathing; Polysomnographic parameter; Cardiovascular risk.

INTRODUCTION

Sleep-disordered breathing (SDB) is a significant community health concern, encompassing conditions like obstructive sleep apnea (OSA) and central sleep apnea. It is connected with a heightened risk of cardiovascular diseases (CVDs), especially in individuals with obesity. SDB, even in milder forms, stresses the cardiovascular system, leading to complications for instance hypertension, coronary heart disease, heart failure, arrhythmias, and stroke. This multifaceted disorder has garnered substantial attention due to its increasing prevalence, especially among individuals with obesity, as a result, understanding the intricate interplay between SDB and cardiovascular complications has become imperative in contemporary medicine **(1)**.

Cardiovascular pathophysiologies may result from nighttime breathing difficulties, such as sleep loss, periodic hypoxia, and chest pressure fluctuations. Systemic inflammation, oxidative stress, and sympathetic nervous system stimulation induced by SDB cause endothelial dysfunction and atherosclerosis **(2)**.

Consequently, the evaluation of cardiovascular parameters from interpreting Polysomnography

(PSG) has become essential in identifying individuals at risk of these potentially life-threatening complications. PSG; a comprehensive diagnostic tool often referred to as the "gold standard" for assessing sleep disorders, plays a pivotal role in unraveling the complexities of SDB. PSG includes a stay for the night in a specialized sleep laboratory where an array of physiological parameters is meticulously monitored **(3)**.

OSA diagnosis relies on the AHI, which is derived by dividing apneas and hypopneas by sleep duration. Cutoff criteria define OSA severity in AHI standards. Mild OSA comprises five to fifteen episodes in one hour, moderate fifteen to thirty, and severe if more than thirty. The American Academy of Sleep Medicine (AASM) established the ICSD-3 Central Sleep Apnea diagnostic criteria, according to **(4)**. Frequent central apneas (cessation of airflow for 10 seconds without effort) on polysomnography (PSG) are required to diagnose CSA.

While the apnea/hypopnea index (AHI) has traditionally implemented as a cornerstone in assessing SDB severity and its relationship with cardiovascular outcomes, recent research has shed light on the limitations of this approach. AHI primarily quantifies the frequency of respiratory events during sleep but fails to capture critical aspects such as the magnitude of oxygen desaturation, which may exert significant effects on various organs and should be included and interpreted within the PSG framework. In light of these developments, there is a growing need to explore and emphasize additional polysomnographic parameters beyond AHI that can provide a more comprehensive assessment of the cardiovascular implications of SDB **(5)**.

PSG parameters such as oxygen desaturation index (ODI), sleep duration, blood pressure decrease, T<90%, arousal index, and pulse rate variability per hour provide a comprehensive cardiovascular assessment in SDB patients. These assessments show SDB severity, hypoxemia, sleep disruption, and cardiovascular health impacts **(6-9)**.

METHODS

The study is a comparative retrospective cross-sectional study (no-risk group versus high-risk group) was carried out in the Sleep-disordered breathing unit, Chest Department, Faculty of Medicine, Zagazig University Hospitals from December 2022 to December 2023; approved by Zagazig University Institutional Review Board (IRB).

Population of the study:

The study included two hundred and eighteen patients with sleep breathing disorders who encountered the inclusion criteria, they were distributed to 2 equal subgroups (Patients with cardiac disease and patients without), with their age range from 20-75 years, they were 118 males and 100 females.

Inclusion Criteria:

Adult patients (more than 18 years) with sleep disorder symptoms; confirmed by PSG in our sleep unit after the assignment of informed written consent by patients or their relatives.

Exclusion Criteria:

Subjects with underlying uncontrolled chest diseases, Patients with diagnosed 1ry (congenital or rheumatic) heart diseases, Patients on CPAP treatment, and subjects with drug-induced sleep disorders (patients on anti-epileptics, tricyclic antidepressants, or hypnotics).

The following was done for all patients:

1. Full patient history (from patient′s records) including;

a) Personal history (age, gender, residence, occupation &special habits).

b) Full sleep-disordered breathing history including night symptoms (snoring- observed apnea-chocking- nocturnal polyuria- insomnia- no dreams) and daytime symptoms (difficulty waking up dry mouth on waking- morning headache- excessive daytime sleepiness-tiredness- irritability- a car accident or near accident – sexual dysfunction- behavioral problems).

c) Duration of illness.

d) Comorbidities: Respiratory (COPD, Bronchial Asthma) and others (DM, HTN) and chronic drug intake.

e) History of previous ICU admission: which ICU (Respiratory ICU, general ICU, or CCU), cause, duration of stay, mechanical ventilation or not, medications after discharge.

f) Cardiac symptoms, duration, and medications used were recorded (History and confirmed by medical reports).

2. Full Clinical examination: General examination including head & neck examination, body weight, height, and local chest examination.

Neck circumference (NC): This measurement indicates where subcutaneous fatty tissue is distributed over the upper body. According to reports, the ideal cut-off values to identify people with central obesity may be NC >37 cm in males and NC >34 cm in females **(10)**.

Standing erect, non-stretchable plastic tape was used to measure NC midway in the neck, between the mid-cervical spine and the mid-anterior neck. In males, it was measured slightly below the laryngeal prominence, or Adam's apple. The subject was told to look straight ahead, shoulders down but not slumped **(11)**.

3. Assessment of sleep breathing disorders by different scores: (Epworth sleepiness scale, Berlin questionnaire, STOP BANG score, and modified Mallampati score).
4. PSG was done at the unit of sleep-disordered breathing, Department of Chest, Zagazig University hospitals.

A whole-night attended polysomnographic sleep study was completed with (SOMNO screen™ plus (SOMNO medics, in Germany) (Fig1). It encompassed electroencephalography (EEG), electrooculography (EOG), electrocardiography (ECG), submental and anterior tibial Electromyography (EMG), respiratory effort (abdominal and thoracic one), along with measurement of airflow across the nose and mouth, and oxygen saturation **(12)**.

Total sleep duration, sleep latency, sleep phases, and sleep efficiency, which is a crucial metric that represents the proportion of sleep a person gets compared to their bedtime duration. Normal sleep efficiency is thought to be 80% or higher. The majority of people have sleep efficiencies above 90% **(13)**.

1. Respiratory analysis includes:

a. Apnea hypopnea index (AHI): means the average number of apneic and hypopneic events for an hour of sleep and is used in determining OSA severity. OSA is categorized as: **(14)**.

- Mild when the AHI is **5-15** events/hr.
- Moderate at **15-30** events/hr.
- Severe at > **30** events/hr.

b. Respiratory effort-related arousal (RERA): is known as increasing respiratory effort for at least 2 breaths or for at least a period of 10 seconds, associated with a flattening of the inspiratory portion of the nasal airflow, resulting in arousal from sleep **(15)**.

c. Respiratory disturbance index (RDI) is a measurement of the average frequency of hypopnea, obstructive apnea, *and respiratory* effort-related arousal per sleep hour. The method for calculating the RDI is = (RERAs + Hypopneas + Apneas) / TST (in hours) **(16)**.

2. Oxygen saturation includes:

- Baseline oxygen saturation
- Minimal SpO_2
- SpO2 below 90%

ODI (oxygen desaturation index): the hourly desaturation events that occur while sleeping (recorded at 3% desaturation) **(14)**.

3. Heart rate including:

- Minimal HR
- Maximum HR
- Arrhythmias index

4. Snoring analysis in the form of snore index: the number of snoring episodes divided by the hours of total sleep time.
5. Arousals are defined as any abrupt shift in the Electroencephalogram (EEG) from a deeper to a lighter stage of sleep. "It could be associated with an apnea, a hypopnea, a leg movement, or it might just be classified as "spontaneous," implying that there was no obvious cause for it. Arousal Index: is a measure of how often a person is aroused or awakened from sleep. It is detected by dividing the number of arousals and awakenings by the total duration of sleep. The normal range of sleep arousal index varies by age, but it is generally between 10 and 25 in adults **(17)**.
6. Blood pressure monitoring, maximum and minimum systolic pressures, and Diastolic dipping are determined by the percent of the decrease in mean systolic pressure between daytime and nighttime in comparison to the day value. 10 to 20 % is considered normal **(18)**.
7. Pulse transit time and circulatory delay.
8. Body Position and periodic limb movement index.

STATISTICAL ANALYSIS

SPSS version 29 was used for data processing, checking, entering, and analysis. The current study's results were analyzed using the following statistical techniques. For qualitative variables, the data were presented as a number and a percentage, and for quantitative variables, as mean + standard deviation (SD). The method used for the comparison was;

1. The student "t" test for comparison of means of two independent groups.
2. Mann-Whitney test was used to calculate the difference between quantitative variables in not normally distributed data in two groups.
3. The chi-square test (X2) was used to find the association between row and column variables.
4. Pearson correlation: used to find the correlation between variables.

Level of significance: For all the above-mentioned statistical tests done, the threshold of significance was fixed at a 5% level (*P* value). The level of statistical significance was set at $P < 0.05$, and a Highly significant difference was present if $P \leq 0.001$.

ROC curve: A graphical figure known as a receiver operating characteristic (ROC) shows how well a binary classifier system performs when its discrimination threshold is changed. Plotting the percentage of true positives out of positives (TPR=true positive rate) against the percentage of false positives out of negatives (FPR=false positive rate) at different threshold values yields this result. FPR, or true negative rate, is one less than specificity, while TPR is also referred to as sensitivity. ROC analysis offers instruments for identifying potentially ideal models and eliminating less-than-ideal ones.

RESULTS

Table (1) shows that there is no statistically significant difference in the age, duration of Illness, and neck circumference (*P* value 0.53, 0.76, and 0.50 respectively). Gender distribution reveals a significant difference between the two groups (*P* value 0.01) with female predilection in the cardiac group (54.13%) compared to the non-cardiac group (38.53%).

Figure (2) shows that comorbidities such as bronchial asthma (B.A) and diabetes mellitus (DM) are significantly more prevalent in the cardiac group ($P = 0.009$) compared to the non-cardiac group ($P < .001$). Conversely, chronic obstructive pulmonary disease (COPD) does not show a significant difference ($P = 0.17$), while interstitial lung disease (ILD) also does not significantly differ ($P = 0.18$) between the two groups.

Figures (3) and (4) demonstrate that there was no significant difference in the night and daytime symptoms between the two groups under study ($P >0.05$).

Table (2) shows that (44.95%) of the cardiac group required ICU admission compared to (14.81%) of the non-cardiac group with a highly significant difference among the 2 groups ($P < .001$). Concerning mechanical ventilation, the rates of mechanical ventilation were nearly identical between the two groups ($P = 0.98$).

Table (S1) demonstrates that the Apnea-Hypopnea Index (AHI) displays no significant difference between the cardiac and non-cardiac individuals, with *P* value = 0.95. Moreover; there is a lack of statistical significance between both groups regarding the severity of SDB.

Table (S2) shows that there is a very highly significant difference, signifying a lower prevalence of OSA in the "Cardiac" group in relation to the "Non-Cardiac" cluster. Mixed sleep apnea was diagnosed more in the cardiac group (39.45%) compared to the non-cardiac group (13.89%) with a *P* value < .001, indicating a substantial increase in mixed sleep apnea diagnoses among cardiac patients.

Table (S3) shows that the "Cardiac" group exhibits a significantly higher ODI (39.62) compared to the "Non-Cardiac" group (21.77), indicating a more pronounced occurrence of oxygen desaturation events during sleep in the cardiac group (*P* value < .001). Subjects in the "Cardiac" group spent significantly more periods with oxygen saturation less than 90% during sleep (25.35%) compared to those in the "Non-Cardiac" group (9.85%), with a *P* value < .001. The Arousal index is markedly greater in the "Cardiac" group (19.61) in relation to the "Non-Cardiac" group (12.82), indicating more frequent sleep disruptions or awakenings during the night in the cardiac population (*P* value < .001). Significantly subjects in the "Non-Cardiac" group exhibit more diastolic dipping of blood pressure (90.74%) in relation to the "Cardiac" group (18.35%) with a *P* value < .001. **Moreover,** the "Cardiac" group has a significantly higher arrhythmia index (76.85) than the "Non-Cardiac" group (14.27), indicating a greater occurrence of abnormal heart rhythms during sleep in this group (*P* value < .001).

Table (S4) This table demonstrates that the Arousal Index had a cutoff value of **7.5**, exhibiting an AUC of 0.756, a sensitivity of 96.3%, a specificity of 81.5%, and a highly significant *P* value < 0.001 Figure (S1).

Similarly, the Arrhythmia Index featured a cutoff value of **2.1**, an impressive AUC of 0.937, a sensitivity of 97.2%, a specificity of 75.9%, and a *P* value < .001, signifying its strong predictive value. Furthermore, the Apnea-Hypopnea Index per hour (AHI) displayed a cutoff value of **5.5**, an outstanding AUC of 1.000, a sensitivity of 96.3%, and an exceptional specificity of 100%, accompanied by a highly significant *P* value <0.001 Figure (S2).

The oxygen desaturation index (ODI) showed a cutoff value of **6.15**, an AUC of .725, a sensitivity of 97.2%, and a specificity of 92.6%, accompanied by a highly significant *P* value < .001. Time of sleep

below 90% (T<90%) showed a cutoff value of **2.25**, an AUC of .725, a sensitivity of 98.2%, and a specificity of 88.9%, accompanied by a highly significant.

Table 1: Demographic data of both cardiac and non-cardiac individuals

	Cardiac (N = 109)	**Non-Cardiac (N = 109)**	***P*. Value**
Age	48.83 ± 7.19	49.69 ± 12.71	0.53
Gender			
Male	50 (45.87%)	67 (61.47%)	0.01
Female	59 (54.13%)	42 (38.53%)	
Duration of illness (years)	3.29 ± 1.29	3.24 ± 1.31	0.76
BMI			
Underweight	0 (0%)	0 (0%)	-
Healthy	2 (1.84%)	0 (0%)	0.49
Overweight	18 (16.51%)	12 (11.11%)	0.24
Morbid obesity	89 (81.65%)	97 (88.89%)	0.13
Neck Circumference			
≤ 40	26 (23.85%)	30 (27.78%)	0.50
> 40	83 (76.15%)	78 (72.22%)	0.50

Table 2: ICU admission and Mechanical ventilation in both studied groups

	Cardiac (N = 109)	**Non-Cardiac (N = 109)**	*P*. Value
ICU Admission			
Yes	49 (44.95%)	16 (14.68%)	< .001
No	60 (55.05%)	93 (85.32%)	
Invasive Mechanical Ventilation	7 (6.42%)	8 (6.48%)	0.98

Table 3: Pattern of cardiac presentation among the studied Cardiac group

	Cardiac (N = 109)
Uncontrolled Hypertension	83 (76.15%)
Coronary Heart Disease	45 (41.28%)
Atrial Fibrillation	20 (18.35%)
Cardiac Failure	37 (33.94%)

Figure 1: SOMNO screen™ plus

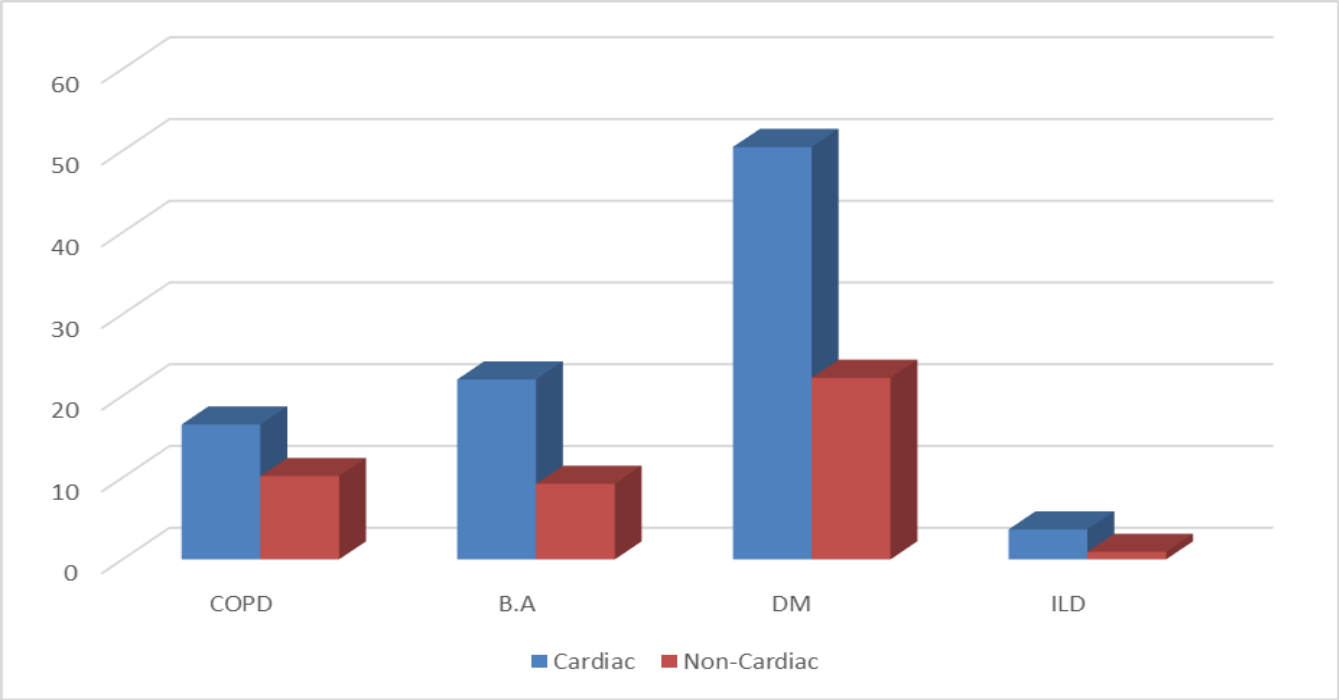

Figure 2: Bar chart illustrating Comorbidities among both studied groups

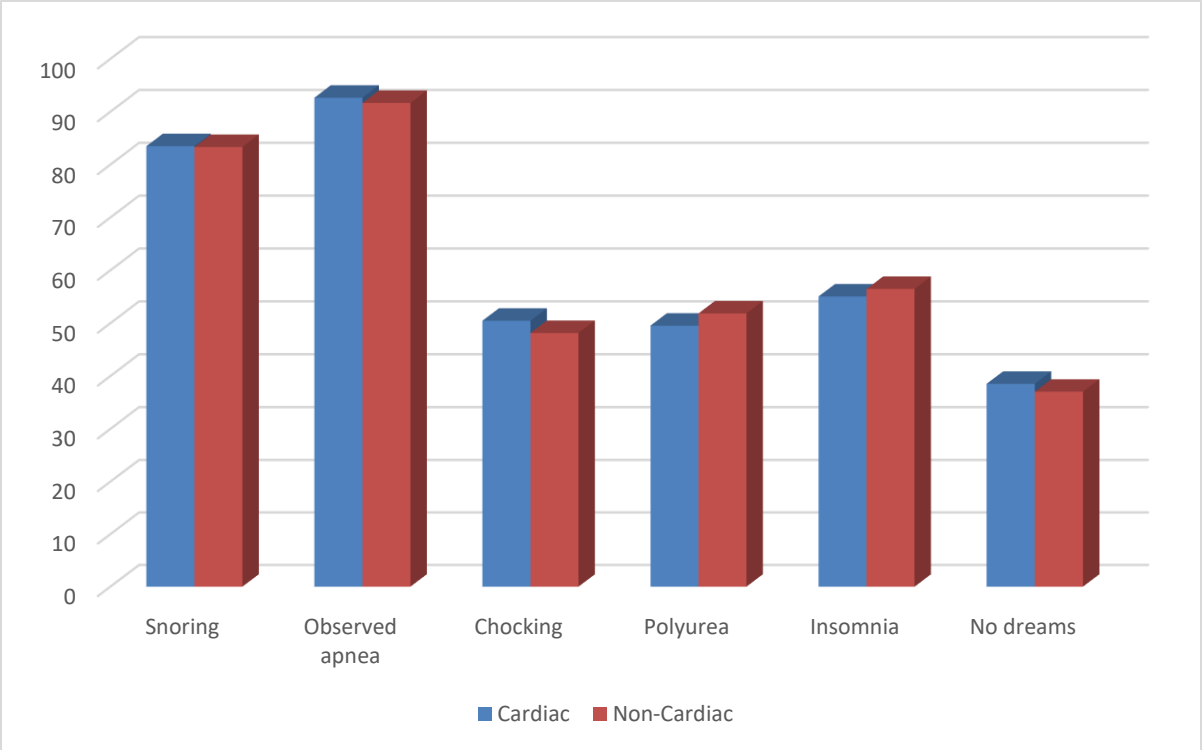

Figure 3: Bar chart of night Symptoms among both studied groups

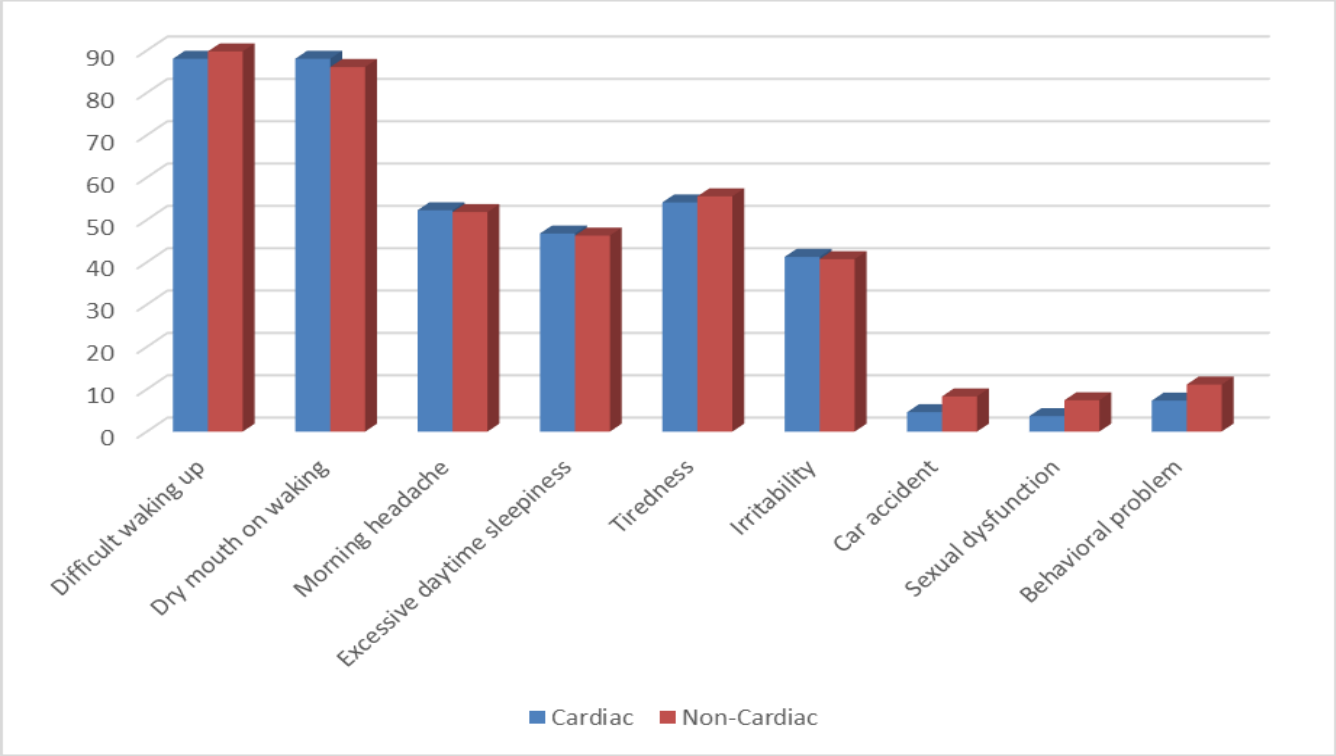

Figure 4: Bar chart of daytime Symptoms among both studied groups

DISCUSSION

Sleep-disordered breathing (SDB) incorporates a spectrum of respiratory disturbances during sleep and has emerged as a significant public health concern with far-reachingimplications for human health. SDB comprises conditions such as obstructive sleep apnea (OSA), central sleep apnea (CSA), and hypoventilation syndromes distinguished by recurrent incidents of either whole or partial airflow obstruction and irregular breathing patterns during sleep. This multidimensional disorder has garnered substantial attention due to its increasing prevalence, especially among individuals with obesity, and its demonstrated association with a heightened risk of cardiovascular diseases (CVDs) **(1)**.

SDB, causes the cardiovascular system to experience acute stress, even in its lesser versions through mechanisms such as intermittent hypoxemia, re-oxygenation, abrupt pleural pressure fluctuations, and frequent awakenings of the central nervous system. Moreover, prolonged untreated SDB significantly raises the possibility of generating a variety of CVDs, comprising hypertension, coronary heart disease (CHD), heart failure (HF), arrhythmias, and stroke, ultimately contributing to a higher mortality risk **(19, 20)**.

While the apnea/hypopnea index (AHI) has traditionally implemented as a cornerstone in assessing SDB severity and its relationship with cardiovascular outcomes, recent research has shed light on the limitations of this approach. In light of these developments, there is a growing need to explore and emphasize additional polysomnographic parameters beyond AHI that can provide a more comprehensive assessment of the cardiovascular implications of SDB **(5)** .

This study's objective was to evaluate the connection among polysomnographic parameters beyond AHI and the identification of cardiovascular complications in patients with SDB.

This study involved 109 participants with cardiac conditions and 109 participants without cardiac conditions. As regards demographic data, Age differences between the cardiac and non-cardiac patient groups were not statistically significant, highlighting its limited influence as a discriminating factor in this study. However, a notable gender distribution discrepancy was evident, with a female predilection in the cardiac group compared to the non-cardiac group. Additionally, variables such as duration of illness, body mass index (BMI), and neck circumference displayed no significant distinctions among the groups, suggesting their secondary roles in contributing to the observed differences in sleep-

disordered breathing and accompanying cardiovascular complications. Notably, both groups exhibited a substantial prevalence of morbid obesity, emphasizing the critical importance of weight management and interventions targeting obesity in addressing sleep-disordered breathing and its concomitant cardiovascular risks. Current findings align with the research conducted by **Erridge et al., (2021) (21)** in obese patients, where they identified several comorbidities associated with a higher chance of obstructive sleep apnea (OSA).

Here, we observed a higher incidence of conditions such as bronchial asthma and diabetes mellitus in the cardiac group compared to the non-cardiac group. Both bronchial asthma and diabetes mellitus are recognized to be linked to a higher risk of cardiovascular complications, and sleep apnea is recognized as a contributing element for these conditions. The underlying mechanisms linking these associations involve chronic inflammation, oxidative stress, and autonomic dysfunction. **Medvedeva et al., (2022) (22)** also reported a sizable proportion of patients received a diabetes mellitus diagnosis. This indicates a considerable prevalence of diabetes within the population of heart failure patients they studied.

There was no statistically significant difference between the two groups in the current investigation concerning these reported night and day symptoms. Despite the lack of statistical significance, snoring, apnea, difficulty walking up and daytime sleepiness were highly prevalent in both groups. The study findings were in accord with those of **Platon et al., (2023) (23)** as described in their review; snoring and daytime sleepiness emerge as some of the most frequently encountered symptoms.

In this study, a notable disparity in ICU admission rates emerged, with a higher proportion of patients in the cardiac group requiring ICU admission related to their non-cardiac counterparts. This observation carries significant medical implications, emphasizing the potential gravity of sleep-disordered breathing in individuals with underlying cardiac conditions. **Chen et al. (24)** systematic review found that both acute and CHD patients had a higher incidence of obstructive sleep apnea, establishing it as a significant coronary heart disease risk factor, and increased need for ICU admission with prolonged ICU stay. OSA was linked to an augmented risk of coronary atherosclerosis that may be linked to connected to chronic inflammation of blood vessels, vascular oxidation emergency, and vascular endothelial insult.

Regarding cardiac patients in this study, mixed sleep apnea was substantially more prevalent, at 39.45%, compared to 13.89% in non-cardiac individuals. However, among cardiac patients, 57.8% were diagnosed with obstructive sleep apnea (OSA), while in non- cardiac individuals, OSA prevalence was notably higher at 86.11%.

This contrast highlights OSA as more common in those without cardiac conditions inconsistent with **Donovan & Kapur (25)** who reported that OSA is far more probable than CSA to be the cause of SDB in individuals with heart failure. Central sleep apnea (CSA) was minimally present in both groups. The notably higher prevalence of mixed sleep apnea in cardiac patients compared to non-cardiac individuals can be attributed to disruptions in the autonomic nervous system and cardiovascular control, impacting the central respiratory drive and leading to central sleep apneas.

In contrast, several other polysomnographic parameters, including the Oxygen Desaturation Index (ODI), arousal index, and arrhythmia index, exhibited significant differences in the cardiac patient group compared to the non-cardiac group, with *P* values consistently <0.001. These differences emphasize how crucial it is to take into account variables other than AHI in assessing cardiovascular risk in SDB patients.

Moreover, the current study revealed compelling positive correlations between cardiac complications and various polysomnographic parameters, including the arousal index, arrhythmia index, AHI, ODI, and T<90%, These correlations emphasize the intricate interplay between sleep disruption, oxygen saturation, autonomic dysregulation, and cardiovascular outcomes in SDB patients.

Additionally, the study assessed the predictive value of these parameters. The Arousal Index, with a cutoff of **7.5**, exhibited an AUC of 0.756, 96.3% sensitivity, 81.5% specificity, and a *P* value <0.001. Similarly, the Arrhythmia Index, with a cutoff of **2.1**, demonstrated impressive predictive value with an AUC of 0.937, 97.2% sensitivity, 75.9% specificity, and a *P* value <0.001. The Apnea-Hypopnea Index per hour (AHI), with a cutoff of **5.5**, showed perfect predictive capability with an AUC of 1.000, 96.3% sensitivity, 100% specificity, and a *P* value <0.001. The Oxygen Desaturation Index (ODI), with a cutoff of **6.15**, revealed strong predictive potential, featuring an AUC of 0.725, 97.2% sensitivity, 92.6% specificity, and a *P* value <0.001.

Lastly, the Time of sleep below 90% (T<90%), with a cutoff of **2.25**, displayed robust predictive power, including an AUC of 0.725, 98.2% sensitivity, 88.9% specificity, and a *P* value <0.001. These results emphasize the significance of these parameters in assessing cardiovascular risk in SDB patients.

The study findings are consistent with prior research by **Huang et al. (26)** which similarly found no association between AHI and outcomes in cardiac patients.

Previous studies have demonstrated that measurements of hypoxia, such as ODI, can predict conditions like atrial fibrillation, sudden cardiac death, and mortality in patients with stable heart failure as mentioned by **Arnaud et al. (27) , Kim et al. (28) ،Redline et al. (29) and Zaffanello et al. (30).**

Moreover, the current findings align with the research conducted by **Suzuki et al. (31)** on patients with obstructive sleep apnea syndrome, which demonstrated significant positive correlations between arousal index, and oxygen desaturation index with carotid artery atherosclerosis.

Similarly, **Thunström et al. (32)** reported that obstructive sleep apnea with an oxygen desaturation index of ≥ 5 was connected to elevated inflammatory activity in a nonobese coronary artery disease cohort. This underscores the broader impact of oxygen desaturation in SDB patients beyond just cardiovascular risk. And also **Peker et al. (33)** described that the ODI is linked to a higher chance of incident cardiovascular disease.

Time of sleep below 90% saturation (T<90%) shows strong associations in this study with a cardiac patient group with a *P* value < 0.001 and this is consistent with **Punjabi et al. (34)** discovered a connection among cardiovascular-related mortality and prolonged oxygen desaturation (TST below 90 > 70% of the total time of sleep). This study revealed a negative correlation with diastolic blood pressure dipping (with a *P* value < 0.001). Diastolic dipping of blood pressure refers to the normal physiological decrease in blood pressure during sleep compared to wakefulness. Non-dipping or reverse dipping patterns, where blood pressure remains elevated during sleep are linked to a higher risk of cardiovascular illnesses, such as hypertension, left ventricular hypertrophy, and stroke as stated by **Khoshkish et al. (35) and Mokhlesi et al. (36)**. The current findings are in settlement with **Crinion et al. (37) and Luo et al. (38)** who had focused on the association of diastolic blood pressure dipping with OSA, and stated that non-dipping subjects with elevated blood pressure should be checked for OSA, especially if other clinical features support this possibility.

CONCLUSION

Polysomnographic parameters other than AHI, such as Oxygen Desaturation Index, Time of sleep below 90%, Arrhythmia Index, Arousal Index, and Diastolic Dipping of BP emerge as a key marker of heightened risk of cardiovascular complications.

Conflict of interest: None

Financial disclosures: None

REFERENCES

1. Kadhim, K. I. (2022). Sleep-Disordered Breathing and Atrial Fibrillation: Prevalence, Detection and Mechanistic Insights at https://hdl.handle.net/2440/135598.
2. Chen, J., Lin, S., & Zeng, Y. (2021). An update on obstructive sleep apnea for atherosclerosis: mechanism, diagnosis, and treatment. Frontiers in cardiovascular medicine, 8, 647071.
3. Ramamurthy, M. B. (2022). Sleep Diagnostics. In Paediatric Sleep Disorders: Case-based Practical Guide (pp. 35-42): Springer.
4. Sateia, M. J. (2014). International classification of sleep disorders. Chest, 146(5), 1387-1394.
5. Pevernagie, D. A., Gnidovec-Strazisar, B., Grote, L., Heinzer, R., McNicholas, W. T., Penzel, T., et al. (2020). On the rise and fall of the apnea/hypopnea index: A historical review and critical appraisal. Journal of sleep research, 29(4), e13066.
6. Wali, S. O., Abaalkhail, B., AlQassas, I., Alhejaili, F., Spence, D. W., & Pandi-Perumal, S. R. (2020). The correlation between oxygen saturation indices and standard obstructive sleep apnea severity. Annals of thoracic medicine, 15(2), 70.
7. Ma, C., Zhang, Y., Liu, J., & Sun, G. (2021). A novel parameter is better than the AHI for assessing nocturnal hypoxemia and excessive daytime sleepiness in obstructive sleep apnoea. Scientific Reports, 11(1), 4702.
8. Varghese, L., Rebekah, G., Priya, N., Oliver, A., & Kurien, R. (2022). Oxygen desaturation index as an alternative parameter in screening patients with severe obstructive sleep apnea. Sleep Science, 15(Spec 1), 224.
9. Cao, W., Luo, J., Huang, R., & Xiao, Y. (2023). Implication of a novel measure of obstructive sleep apnea severity for cardiovascular morbidity. Sleep Medicine, 103, 204-210.
10. Yang GR, Yuan SY, Fu HJ, et al., (2010): Neck circumference positively related with central obesity, overweight, and metabolic syndrome in Chinese

subjects with type 2 diabetes: Beijing community diabetes study 4, Diabetes Care, 33:2465-7.
11. Aswathappa J, Garg S, Kutty K, Shankar V (2013): Neck circumference as an anthropometric measure of obesity in diabetics, North Am J Med Sci, 5:28-31.
12. Redline S, Sanders MH, Lind BK, et al., (1998): Methods for obtaining and analyzing unattended polysomnography data for a multicenter study. Sleep Heart Health Research Group, Sleep, 21(7):759-67. PMID: 11300121.
13. Ohayon MM, Carskadon MA, et al., (2004): Meta-analysis of quantitative sleep parameters from childhood to old age in healthy individuals: developing normative sleep values across the human lifespan, Sleep, 27:1255–1273.
14. Roche, Johanna, Gillet Valérie, Perret Frédéric, et al., (2018): "Obstructive sleep apnea and sleep architecture in adolescents with severe obesity: effects of a 9-month lifestyle modification program based on regular exercise and a balanced diet." Journal of Clinical Sleep Medicine 14.6. 967-976.
15. Laratta, Cheryl R., Tsai Willis H., Pendharkar Sachin R., A. et al., (2017): "Validity of administrative data for identification of obstructive sleep apnea." Journal of sleep research 26.2. 132-138.
16. Berry RB, Brooks R, Gamaldo CE, et al., (2016): The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications, Version 2.3. Darien, Illinois: American Academy of Sleep Medicine; 2016; Available from URL:www.aasmnet.org (accessed September 2017).
17. Katz, Eliot S., Lutz Janita, Marcus Carole L et al., (2003): "Pulse transit time as a measure of arousal and respiratory effort in children with sleep-disordered breathing. " Pediatric research 53.4. 580-588.
18. Crinion, S. J., Ryan, S., Kleinerova, J., Kent, B. D., Gallagher, J., Ledwidge, M., et al. (2019). Nondipping nocturnal blood pressure predicts sleep apnea in patients with hypertension. Journal of Clinical Sleep Medicine, 15(7), 957-963.
19. Anand, A., Patel, J., & Pogach, M. (2023). The Role of Sleep Apnea in Diabetes Mellitus and Cardiovascular Disease. Diabetes and Cardiovascular Disease, 333-374.
20. Rajachandran, M., Nickel, N., & Lange, R. A. (2023). Sleep apnea and cardiovascular risk. Current Opinion in Cardiology, 38(5), 456-461.
21. Erridge, S., Moussa, O., McIntyre, C., Hariri, A., Tolley, N., Kotecha, B., et al. (2021). Obstructive sleep apnea in obese patients: a UK population analysis. Obesity surgery, 31, 1986-1993.
22. Medvedeva, E., Korostovtseva, L., Bochkarev, M., Shumeiko, A., Berezina, A., Simonenko, M., et al. (2022). The Prognostic Role of Polysomnography Parameters in Heart Failure Patients with Previous Decompensation. Journal of Clinical Medicine, 11(13), 3656.
23. Platon, A. L., Stelea, C. G., Boișteanu, O., Patrascanu, E., Zetu, I. N., Roșu, S. N., et al. (2023). An Update on Obstructive Sleep Apnea Syndrome—A Literature Review. Medicina, 59(8), 1459.
24. Chen, L., Zou, S., & Wang, J. (2022). Association of Obstructive Sleep Apnea Syndrome (OSA/OSAHS) with Coronary Atherosclerosis Risk: Systematic Review and Meta-Analysis. Computational and Mathematical Methods in Medicine, 2022.
25. Donovan, L. M., & Kapur, V. K. (2016). Prevalence and characteristics of central compared to obstructive sleep apnea: analyses from the sleep heart health study cohort. Sleep, 39(7), 1353-1359.
26. Huang, Y., Wang, Y., Huang, Y., Zhai, M., Zhou, Q., Zhao, X., et al. (2020). Prognostic value of sleep apnea and nocturnal hypoxemia in patients with decompensated heart failure. Clinical Cardiology, 43(4), 329-337.
27. Arnaud, C., Bochaton, T., Pépin, J.-L., & Belaidi, E. (2020). Obstructive sleep apnoea and cardiovascular consequences: pathophysiological mechanisms. Archives of cardiovascular diseases, 113(5), 350-358.
28. Kim, S., Lee, K. Y., Kim, N. H., Abbott, R. D., Kim, C., Lee, S. K., et al. (2020). Relationship of obstructive sleep apnoea severity and subclinical systemic atherosclerosis. European Respiratory Journal, 55(2).
29. Redline, S., Azarbarzin, A., & Peker, Y. (2023). Obstructive sleep apnoea heterogeneity and cardiovascular disease. Nature Reviews Cardiology, 1-14.
30. Zaffanello, M., Piacentini, G., & La Grutta, S. (2020). The cardiovascular risk in paediatrics: The paradigm of the obstructive sleep apnoea syndrome. Blood Transfusion, 18(3), 217.
31. Suzuki, M., Shimamoto, K., Sekiguchi, H., Harada, T., Satoya, N., Inoue, Y., et al. (2019). Arousal index as a marker of carotid artery atherosclerosis in patients with obstructive sleep apnea syndrome. Sleep and Breathing, 23, 87-94.
32. Thunström, E., Glantz, H., Fu, M., Yucel-Lindberg, T., Petzold, M., Lindberg, K., et al. (2015). Increased inflammatory activity in nonobese patients

with coronary artery disease and obstructive sleep apnea. Sleep, 38(3), 463-471.
33. Peker, Y. k., Hedner, J., Norum, J., Kraiczi, H., & Carlson, J. (2002). Increased incidence of cardiovascular disease in middle-aged men with obstructive sleep apnea: a 7-year follow-up. American journal of respiratory and critical care medicine, 166(2), 159-165.
34. Punjabi, N. M., Caffo, B. S., Goodwin, J. L., Gottlieb, D. J., Newman, A. B., O'Connor, G. T., et al. (2009). Sleep-disordered breathing and mortality: a prospective cohort study. PLoS medicine, 6(8), e1000132.
35. Khoshkish, S., Hohl, M., Linz, B., Arzt, M., Mahfoud, F., Baumert, M., et al. (2018). The association between different features of sleep-disordered breathing and blood pressure: a cross-sectional study. The Journal of Clinical Hypertension, 20(3), 575-581.
36. Mokhlesi, B., Hagen, E. W., Finn, L. A., Hla, K. M., Carter, J. R., & Peppard, P. E. (2015). Obstructive sleep apnoea during REM sleep and incident non-dipping of nocturnal blood pressure: a longitudinal analysis of the Wisconsin Sleep Cohort. Thorax, 70(11), 1062-1069.
37. Crinion, S. J., Ryan, S., Kleinerova, J., Kent, B. D., Gallagher, J., Ledwidge, M., et al. (2019). Nondipping nocturnal blood pressure predicts sleep apnea in patients with hypertension. Journal of Clinical Sleep Medicine, 15(7), 957-963.
38. Luo, Q., Li, N., Zhu, Q., Yao, X., Wang, M., Heizhati, M., et al. (2023). Non-dipping blood pressure pattern is associated with higher risk of new-onset diabetes in hypertensive patients with obstructive sleep apnea: UROSAH data. Frontiers in endocrinology, 14, 1083179.

Table S1: Categorization of Apnea-Hypopnea Index (AHI) and severity in both groups:

	Cardiac (N = 109)	Non-Cardiac (N = 109)	*P* value
Apnea-Hypopnea Index	22.29 ± 12.16	22.19 ± 12.25	0.95
Severity			
Mild	38 (34.86%)	36 (33.33%)	0.81
Moderate	24 (22.02%)	27 (25%)	0.60
Severe	47 (43.12%)	45 (41.67%)	0.82

Table S2: Final Diagnosis in both studied groups

	Cardiac (N = 109)	Non-Cardiac (N = 109)	P. Value
OSA	63 (57.8%)	93 (86.11%)	< .001*
Mixed	43 (39.45%)	16 (13.89%)	< .001*
CSA	3 (2.75%)	0 (0%)	0.25

Table S3: Comparison between both groups regarding Polysomnographic parameters:

	Cardiac (N = 109)	Non-Cardiac (N = 109)	*P*. Value
Oxygen desaturation index (ODI)	39.62 ± 25.97	21.77 ± 17.09	< .001
Time of sleep below 90% (T<90%)	25.35 ± 43.91	9.85 ± 11.73	< .001
Arousal index	19.61 ± 8.2	12.82 ± 6.49	< .001
Diastolic dipping of blood pressure	20 (18.35%)	98 (90.74%)	< .001
Arrhythmia index	76.85 ± 72.16	14.27 ± 12.35	< .001

Table S4: ROC curve analysis of different PSG parameters with cardiac affection

	Cutoff Value	AUC	Standard Error	Sensitivity (%)	Specificity (%)	*P* value
Arousal index	**7.5**	.756	.033	96.3	81.5	<0.001
Arrhythmia index	**2.1**	.937	.018	97.2	75.9	<0.001
AHI	**5.5**	1.000	.000	96.3	100	<0.001
ODI	**6.15**	.725	.035	97.2	92.6	<0.001
T <90%	**2.25**	.725	.034	98.2	88.9	<0.001

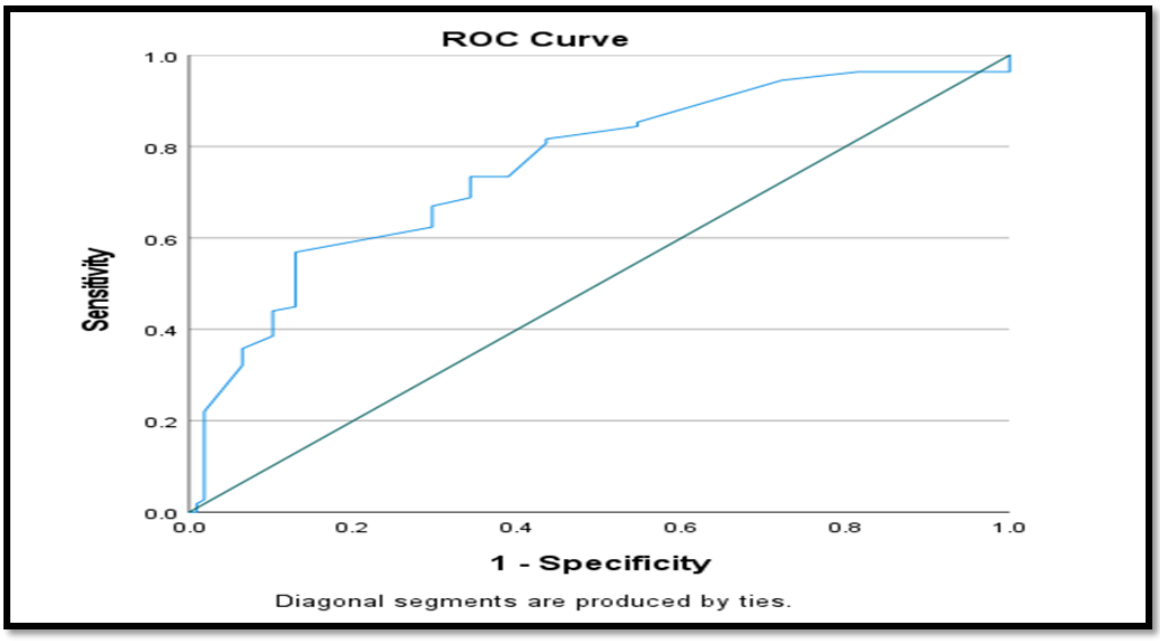

Figure S1: ROC curve analysis of arousal index with cardiac affection

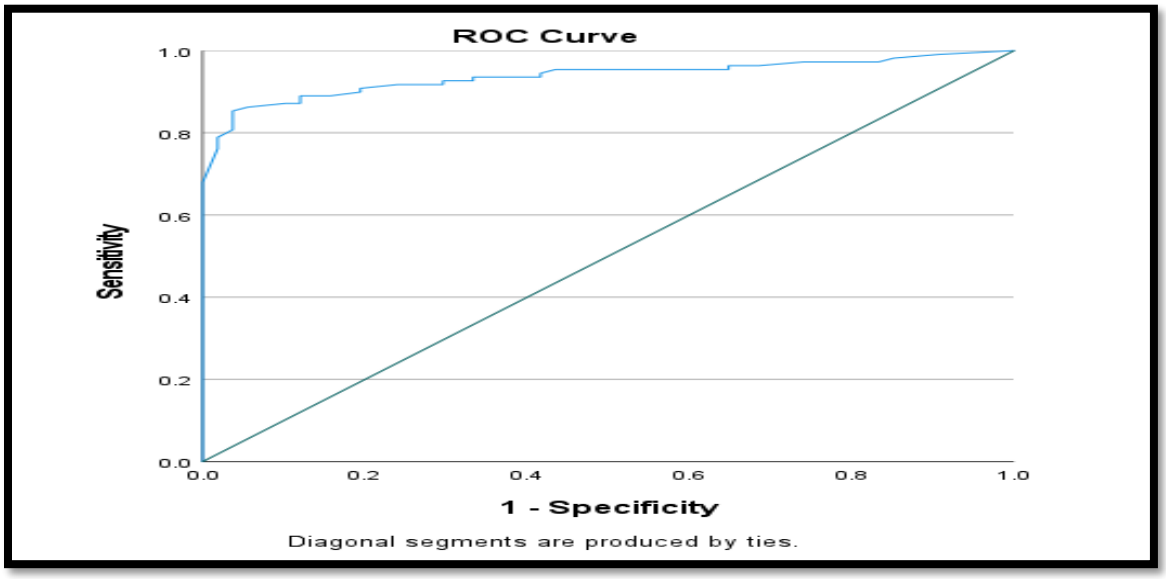

Figure S2: ROC curve analysis of arrhythmia index with cardiac

Citation

Ghoneim, A., Adel, N., Mahmoud, M., Elgendy, W. Polysomnographic Parameters and Assessment of Cardiovascular Complications in Patients with Sleep Disordered Breathing. *Zagazig University Medical Journal*, 2024; (4540-4552): -. doi: 10.21608/zumj.2024.310483.3511