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A Clinical Study on the Prevalence and Risk Factors of Obstructive Sleep Apnea among Chronic Kidney Disease Patients

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KEYWORDS

Obstructive sleep apnea, Chronic kidney disease, Polysomnography, Berlin questionnaire, Adjusted neck circumference, Mallampati scale.

ABSTRACT:

Background: A common issue is that individuals suffering from Chronic Kidney Disease often remain undiagnosed for Obstructive Sleep Apnea (OSA). The incidence of OSA tends to increase as kidney function deteriorates, which poses heightened risks to cardiovascular health and metabolic processes. Early identification of symptoms and the condition itself can assist patients in improving their quality of life and enhance their prospects for recovery.

Aim and Objectives:

- To identify how much OSA occurs in CKD patients at Stages 2–4 and assess risk factors for the disease.
- To examine how OSA affects people in the beginning (Stages 2 and 3) and advanced (Stage 4) stages of chronic kidney disease.
- To find out which factors may lead to OSA among patients with CKD.

Materials and Methods: The study included people with stable chronic kidney disease who were cared for at nephrology and internal medicine outpatient practices. We applied the CKD-EPI equation to find the stage of CKD in all patients. Stage 2 and Stage 3 were included in Group 1 for analysis, and Stage 4 was Group 2 in the same analysis. All participants had their responses evaluated with the Berlin Questionnaire. An RMS Mobile split-night polysomnography was performed to ensure and grade the level of OSA risk in patients. The information used was EEG, EOG, EMG, airflow, respiratory effort, ECG, oxygen saturation, body position, and snoring. Things looked at were the age of the patient, their sex, the duration of chronic kidney disease, diabetes, hypertension, whether fluid was overloaded, their neck size, Mallampati score, and the results of their chemical blood tests.

Results and Discussion: A significantly elevated prevalence of OSA was observed in Group 2 (Stage 4 CKD) compared to Group 1 (Stages 2 and 3). Individuals exhibiting more severe OSA were more prone to experience advanced CKD. The researchers identified several critical risk factors, including older age, male gender, diabetes, hypertension, increased neck circumference, and a higher score on the Mallampati scale. Additionally, excessive fluid retention and a prolonged duration of CKD were both associated with an increased likelihood of OSA.

Conclusion: The occurrence of OSA significantly increases in patients with CKD as their condition deteriorates. Consistently monitoring and responding to early indicators in high-risk CKD patients could

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potentially reduce complications and lead to improved outcomes.

1. Introduction

When an individual suffers from sleep-disordered breathing (SDB), their sleep is frequently characterized by multiple instances of hypopnea and apnea. The issue of dyspnea is prevalent, yet both individuals and healthcare professionals often neglect it, especially those with chronic illnesses. SDB encompasses a variety of conditions, with Obstructive Sleep Apnea (OSA) being the most common. According to Malhotra and White (2023), many adults experience SDB, which can result in numerous complications, including cardiovascular and metabolic issues. A physician will diagnose OSA if a patient exhibits persistent daytime drowsiness and experiences five or more occurrences of breathing cessation or a decrease in blood oxygen levels during sleep (Malhotra & White, 2023).

Chronic Kidney Disease (CKD) patients are more likely to develop SDB because too much fluid in their bodies, sensitive chemoreceptors, and certain metabolic changes can all increase their risk. Many research studies report that over half of patients with advanced kidney dysfunction suffer from SDB (Ramar et al., 2022). According to AASM, an event of hypopnea in OSA means there is at least a 50% decrease in nasal air for 10 seconds, plus a drop in oxygen of 3% or more, or the person wakes up. Due to these pathways, both temporary shortages in oxygen in the blood and sleep interruptions can be very harmful in people who have preexisting CKD.

OSA or OSA Hypopnea Syndrome (OSAHS) results in excessive daytime tiredness, problems with the brain, poor sleep, and a higher likelihood of high blood pressure. Javaheri et al. (2021) found that OSAHS is connected to higher 24-hour blood pressure, higher risk of heart disease, and faster progression of heart disease, especially for those who have renal disease. The frequent drops in oxygen saturation at night, a main symptom of OSAHS, can raise systolic blood pressure by 4–10 mmHg in these patients and lead to more CKD problems (Javaheri et al., 2021).

Although Western studies have thoroughly examined the correlation between chronic kidney disease (CKD) and sleep-disordered breathing (SDB), the available data from India on this subject is notably limited. Research conducted by Rajagopalan et al. (2020) indicates a chronic kidney disease prevalence of only 0.16–0.79% within Indian communities, and limited studies have systematically assessed the prevalence of sleep-disordered breathing in individuals with chronic kidney disease. Due to the substantial prevalence of undiagnosed SDB cases and their possible effects on CKD outcomes, a notable information vacuum exists in the Indian context. This study is to investigate the prevalence and risk factors associated with obstructive sleep apnea (OSA) in Indian patients diagnosed with Stage 2 to Stage 4 chronic kidney disease (CKD).

Aim and Objectives:

- **To identify how much OSA occurs in CKD patients at Stages 2–4 and assess risk factors for the disease.**
- **To examine how OSA affects people in the beginning (Stages 2 and 3) and advanced (Stage 4) stages of chronic kidney disease.**
- **To find out which factors may lead to OSA among patients with CKD.**

2. Methods

The subjects of this study were patients diagnosed with Chronic Kidney Disease (CKD) who attended the outpatient departments of Nephrology and Internal Medicine at a tertiary care institution. All parents and children are provided with written agreement to partake in the study. The study protocol obtained approval from the institution's ethical committee.

Study Population and Grouping

The inclusion criteria were adult patients with chronic kidney disease (CKD) aged 18 years or older, who had sustained steady renal function over the prior three months. Chronic Kidney Disease (CKD) staging was performed using the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration) equation, which estimates the glomerular filtration rate (eGFR) based on blood creatinine concentrations, age, sex, and race, as described by Levey et al. (2009). Patients categorized as Stage 2 and Stage 3 CKD (eGFR 30–89 mL/min/1.73 m^2) were assigned to Group 1 (early CKD), whereas those

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diagnosed as Stage 4 CKD (eGFR 15–29 mL/min/1.73 m²) were assigned to Group 2 (advanced CKD).

Screening for Obstructive Sleep Apnea (OSA)

First, all enrolled participants were evaluated using the Berlin Questionnaire, a validated tool for identifying those at high risk for OSA (Netzer et al., 1999). High-risk participants underwent split-night polysomnography (PSG) using the RMS Mobile Polysomnography System, which enables both diagnostic and therapeutic (CPAP titration) evaluations in one night, adhering to the standards established by the American Academy of Sleep Medicine (AASM) (Berry et al., 2018).

Polysomnographic Measurements

Polysomnographic data collection included:

- Electroencephalography (EEG): Conducted using the 10–20 international standard to monitor cerebral activity across different sleep stages.
- Electrooculography (EOG): Electrodes for the right and left eyes were positioned 1 cm above and below the outer canthus, respectively.
- Electromyography (EMG): Chin EMG electrodes were situated in the submentalis area. Bilateral leg EMG electrodes were affixed to the anterior compartment of the legs.
- **Airflow:** This was monitored through both a nasal thermistor and a pressure transducer to identify instances of apnea and hypopnea.
- **Respiratory effort:** This was evaluated using piezoelectric belts encircling the thorax and abdomen.
- **Electrocardiography (ECG):** A three-lead ECG was recorded continuously throughout the study.
- **Oxygen saturation (SpO_2):** This was assessed using pulse oximetry with sensors placed on the second and third fingers.

Body position and snoring: These were documented using position sensors on the thoracic belt and a snoring sensor located at the midline of the neck.

Risk Factor Evaluation

The subsequent clinical and biochemical parameters were documented and examined as possible risk factors for OSA:

- Age, gender, duration of CKD
- Existence of comorbidities: Diabetes Mellitus and Hypertension
- Fluid overload, evaluated through clinical assessment and weight history
- Neck circumference and Mallampati score (evaluated based on standard anatomical classification) (Shown in figure-1 & 2)
- Pertinent biochemical profile, encompassing hemoglobin, serum creatinine, urea, electrolytes, and albumin

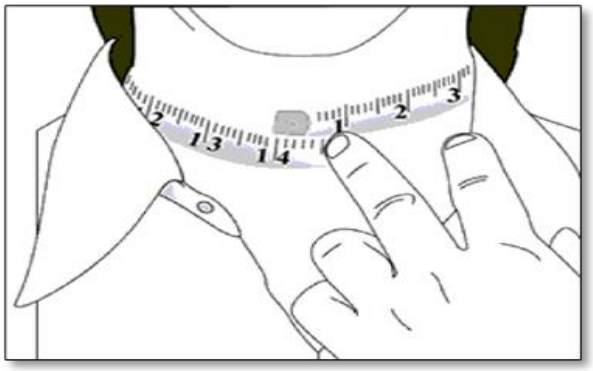

Figure 1: Measurement of neck circumference.

The image demonstrates the proper method for measuring neck circumference with a measuring tape. The tape should be placed horizontally around the neck, just beneath the laryngeal prominence (commonly known as the Adam's apple), ensuring it fits snugly without compressing the skin. Precise measurement of neck circumference is a crucial anthropometric parameter utilized in evaluating risk factors associated with obstructive sleep apnea.

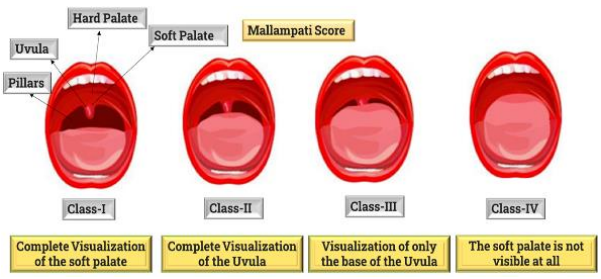

Figure 2: Mallampati Classification for Airway Assessment.

This figure illustrates the four categories of the Mallampati score, which is a clinical instrument utilized to forecast the simplicity of endotracheal intubation and

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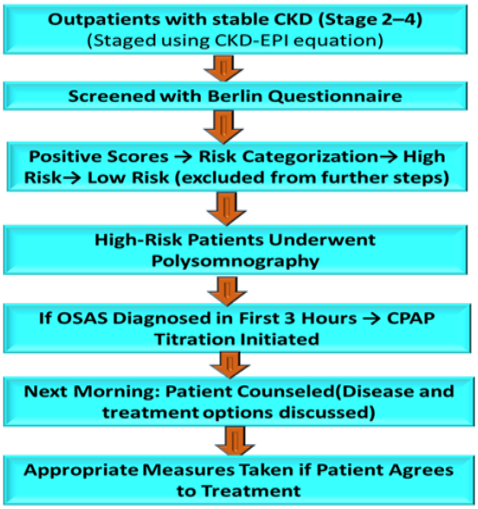
evaluate the likelihood of obstructive sleep apnea (OSA). Class I: Complete visibility of the soft palate, uvula, fauces, and pillars. Class II: Visibility of the soft palate along with the entire uvula. Class III: Visibility restricted to the base of the uvula. Class IV: Only the hard palate is observable; the soft palate remains hidden. Higher Mallampati classes (Class III and IV) correlate with a heightened risk of OSA.

Plan of the Study



Inclusion Criteria

Patients who have been diagnosed with chronic kidney disease (CKD) and possess an estimated glomerular filtration rate (eGFR) ranging from 15 to 89 ml/min (Stages 2 to 4 CKD). A Body Mass Index (BMI) of less than 30 kg/m².

Exclusion Criteria

Patients who have a history of chronic obstructive pulmonary disease (COPD) or bronchial asthma. BMI of 30 kg/m² or higher. eGFR exceeding 90 ml/min (Stage 1 chronic kidney disease). Identified thyroid disorders. Administration of central nervous system (CNS) depressants in the week prior. Ongoing alcohol consumption or alcohol use in the week prior.

Assessment of Outcome

Individuals in both categories (Category 1: CKD Stages 2 and 3; Category 2: CKD Stage 4) identified with obstructive sleep apnea (OSA) via polysomnography were assessed. The intensity of OSA was examined and related to the stage of CKD to determine patterns and correlations.

Ethical Consideration

This research operates as a non-invasive screening procedure. All participants gave their informed consent. Patients diagnosed with OSA were notified of their condition, and follow-up care was guaranteed as part of the responsibilities following the study.

Post-Study Responsibility

All individuals diagnosed with obstructive sleep apnea received counseling regarding their condition. Suitable treatment alternatives were explored, and essential medical interventions were commenced in accordance with the patient's willingness and clinical necessity.

Number of Groups Studied:

- Group 1: Early stage chronic kidney disease patients with eGFR ranging between 30-89ml/min.
- Group 2: Late stage chronic kidney disease patients with eGFR ranging between 15-29 ml/min.

Table-1: Categorization of study participants into two groups according to the stage of chronic kidney disease (CKD) utilizing the estimated glomerular filtration rate (eGFR)

Group 1 Early CKD	eGFR 30-89 ml/min
Group 2 Late CKD	eGFR 15-29ml/min

Screening for obstructive sleep apnea (OSA)

Screening for obstructive sleep apnea (OSA) typically utilizes questionnaires such as the Epworth Sleepiness Scale (ESS), Berlin Questionnaire (BQ), and STOP-BANG. Despite the widespread use of these tools, their diagnostic accuracies vary. The Epworth Sleepiness Scale, designed to assess daytime sleepiness, has demonstrated shortcomings in identifying obstructive sleep apnea. A research by Vana et al. (2013) demonstrated that the ESS had a sensitivity of 66% and a specificity of 48% for detecting OSA, indicating a considerable incidence of false negatives. The BQ, which assesses risk based on snoring habits, daytime

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somnolence, and hypertension, also demonstrates variable efficacy. A meta-analysis conducted by Netzer et al. (1999) revealed that the BQ has a sensitivity of 86% and a specificity of 77% in the detection of OSA. However, alternative studies have demonstrated reduced specificity, perhaps leading to false-positive results.

The STOP-BANG questionnaire, including elements such as snoring, weariness, witnessed apneas, hypertension, BMI, age, neck circumference, and gender, is acknowledged for its considerable sensitivity. Chung et al. (2016) demonstrated that a STOP-BANG score of ≥3 yields a sensitivity of 93% for moderate-to-severe obstructive sleep apnea, however with a diminished specificity of 43%, signifying a trade-off between sensitivity and specificity. Given these variations, no one questionnaire provides optimal accuracy for OSA screening among varied groups. Clinicians often utilize these methods in conjunction with clinical judgment and, when required, confirmatory procedures such as polysomnography to precisely diagnose OSA.

Polysomnography (PSG) method

Polysomnography (PSG) is recognized as the gold standard for diagnosing obstructive sleep apnea (OSA). Kapur, 2017 This comprehensive overnight study is often conducted in a sleep laboratory and involves the continuous monitoring of multiple physiological markers during the sleep duration. The collected data encompasses various domains:

Sleep Channels: Electroencephalogram (EEG) for assessing brain activity, electrooculogram (EOG) for monitoring eye movements, and electromyogram (EMG) for observing muscle activity, particularly in the chin and extremities.(Mayo Clinic Staff, 2021)

Cardiovascular Channels: Electrocardiogram (ECG) to monitor the rhythm and pace of the heart.

Respiratory Channels: Airflow measurement via oronasal thermistors or nasal pressure transducers, thoracoabdominal effort assessed through piezoelectric belts or respiratory inductance plethysmography, and oxygen saturation levels analyzed via pulse oximetry.

These measurements provide a comprehensive assessment of the patient's sleep architecture and breathing patterns, facilitating the accurate diagnosis of OSA and other sleep disorders. Split-night research may be employed in certain cases. This approach entails doing diagnostic polysomnography in the early hours of the night, succeeded by continuous positive airway pressure (CPAP) titration if obstructive sleep apnea (OSA) is promptly detected during the assessment. The split-night strategy facilitates expedited diagnosis and initiation of therapy within one night, enhancing patient convenience and resource efficiency.

Oligosomnography

Oligosomnography refers to sleep tests conducted with a small number of channels, specifically with portable monitors (PMs), and is increasingly utilized for diagnosing obstructive sleep apnea (OSA) when full polysomnography (PSG) is not feasible. In 2007, the American Academy of Sleep Medicine (AASM) published guidelines advocating the utilization of portable monitors (PMs), especially for individuals with a significant likelihood of moderate to severe obstructive sleep apnea (OSA) (Collop et al., 2007). Type III monitors typically record four characteristics: airflow, respiratory effort, ECG or heart rate, and oxygen saturation, while Type IV monitors catch one or two parameters (Kapur et al., 2017). These devices are advantageous for home testing or for patients who are immobile. However, their diagnosis accuracy may be influenced by comorbidities and technical limitations. Consequently, its use should be supervised by sleep specialists and augmented with clinical discretion. PMs provide a pragmatic, but occasionally less comprehensive, substitute for laboratory-based PSG (Collop et al., 2007; Kapur et al., 2017).

Multiple Sleep Latency Test (MSLT)

Most clinical guidelines don’t recommend using the Multiple Sleep Latency Test (MSLT) as a first option for those diagnosed with obstructive sleep apnea (OSA). AASM confirms that professionals use the MSLT to assess whether patients have excessive daytime sleepiness characteristic of narcolepsy or idiopathic hypersomnia, especially when optimized therapy for OSA cannot prevent EDS (Littner et al., 2005; Wise et al., 2018). MSLT results can help to set the baseline for sleepiness before adding any new therapy. Assessing sleepers with suspected sleep disordered breathing demands overnight polysomnography, the AASM explains and routinely using the MSLT is not helpful for

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the evaluation or monitoring of these conditions (Littner et al., 2005).

Maintenance of Wakefulness Test (MWT)

Doctors use the MWT to check if a patient can remain awake despite having little stimulation, especially when daytime sleepiness impairs safety (Littner et al., 2005). MWT is recommended by the American Academy of Sleep Medicine when a proper measurement of wakefulness is required. Diagnosing obstructive sleep apnea (OSA) is still mostly done by polysomnography which records both the structure of sleep and breathing patterns. When patients are bedridden or when just a few parameters are essential, oligosomnography provides valuable assistance (Collop et al., 2007). The Multiple Sleep Latency Test (MSLT) and MWT evaluate distinct facets of sleepiness and alertness. These assessments assist in directing further treatment for patients exhibiting ongoing symptoms. Collectively, they improve diagnostic precision in the field of sleep medicine.

Statistical Analysis: Data was examined utilizing standard statistical software. The prevalence and severity of OSA were compared across the two CKD groups. Associations between clinical variables and OSA were assessed using suitable statistical tests (Chi-square, t-tests, and logistic regression).

3. Results and Discussion

Prevalence of Chronic Kidney Disease Stages 2, 3, and 4 in the Outpatient Population

The CKD-EPI formula confirmed that 64.93% (n=485) of the 747 screened patients were in CKD stages 2, 3, and 4. Only these patients were included in the study. The remaining 262 patients (35.07%) were in stages 1 and 5 and were excluded. This analysis focused exclusively on stages 2, 3, and 4. The findings indicate a higher burden of intermediate CKD stages in the outpatient population.(Shown in figure-3)

Our research indicated that a significant proportion (64.93%) of chronic kidney disease (CKD) patients in outpatient environments are classified into stages 2, 3, and 4 according to the CKD-EPI equation. This observation aligns with previous research, which indicates that stages 2 to 4 are frequently overlooked yet are highly common in both community and clinical environments (Matsushita et al., 2010). These stages signify a crucial opportunity for intervention, where early identification and management could potentially delay the advancement to end-stage renal disease (Levey et al., 2009). The decision to exclude patients in stages 1 and 5 was deliberate to avoid extremes stage 1 typically presents with minimal symptoms and structural alterations, whereas stage 5 encompasses a demographic with intricate comorbidities and modified physiology due to reliance on dialysis, which could distort sleep-related results. By concentrating on stages 2 through 4, this research addresses the portion of CKD where interventions such as screening for sleep apnea might yield the most significant clinical benefits (Inker et al., 2014).

The notable prevalence of intermediate CKD stages highlights the necessity for regular screening in nephrology clinics, not only for assessing renal function but also for identifying related complications like obstructive sleep apnea, which are frequently underdiagnosed and could exacerbate kidney outcomes if not treated.

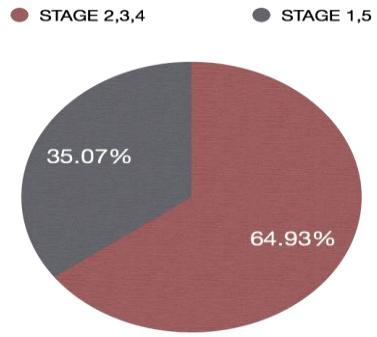

Figure 3: Prevalence of Stage 2,3 and 4 in CKD Population

Distribution of CKD Stages in the Screened Population

Among the population that was screened, Stage 1 chronic kidney disease (CKD) represented 16.33%, Stage 2 constituted 21.68%, Stage 3 comprised 19.14%, Stage 4 made up 24.09%, and Stage 5 accounted for 18.74%. This distribution emphasizes that the majority of patients fell within stages 2 to 4 of CKD.(Shown in figure-4)

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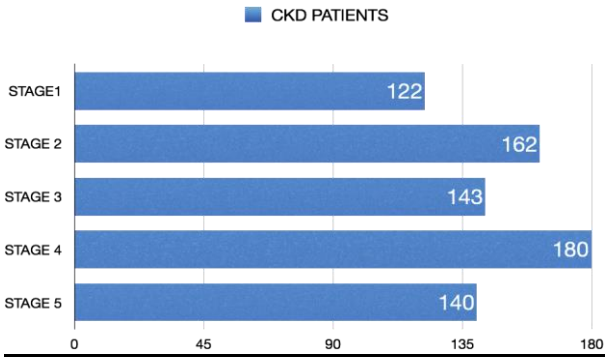
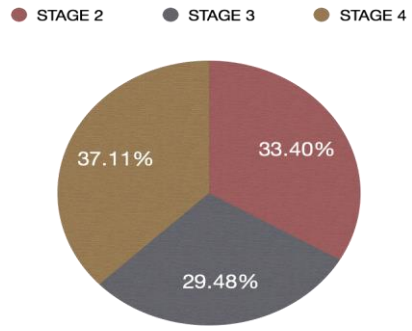


Figure 4: Stage 1,2,3,4 and 5 in CKD population.

Prevalence of Stage 2, 3, and 4 CKD in the Selected Population

Among the 485 patients who participated in the study, 33.40% (n=162) were classified as stage 2, 29.48% (n=143) as stage 3, and 37.11% (n=180) as stage 4 of chronic kidney disease. This indicates a progressive rise in the percentage of patients as the severity of CKD increases, suggesting enhanced detection or referral rates in the later stages. Comparable patterns have been observed in outpatient nephrology cohorts, where stage 4 CKD frequently becomes more clinically evident (Hill et al., 2016). (Shown in figure-5)



N=162 N=143 N=180

Figure 5: Prevalence of Stage 2, 3 and 4 in the selected population.

The prevalence of OSA was measured in CKD patients with the Berlin Questionnaire.

A total of 15.05% (73 patients) among the 485 with CKD were found to have a high risk of obstructive sleep apnea (OSA) using the Berlin Questionnaire. Still, although this method is regularly applied to early screening, it shows different levels of sensitivity and specificity depending on the population analyzed. Since the self-reported form did not always correctly detect sleep apnea in these patients, its results may not accurately reflect the actual number of cases. It has been reported by earlier research such as that of Ramachandran et al. (2010), that the Berlin Questionnaire can miss 38% of cases, meaning OSA prevalence is likely lower than shown by the test. Consequently, even though the Berlin Questionnaire is valuable, polysomnography continues to be necessary for a definite diagnosis in those with CKD. (Shown in figure-6)

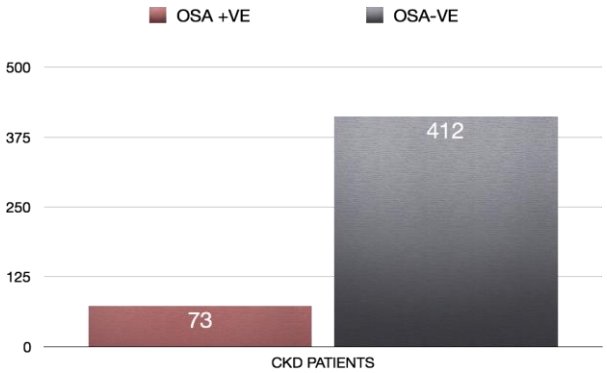


Figure 6: Prevalence of OSA in Stage 2,3 and 4 using Berlin questionnaire

Sex Distribution in the Study Population Undergoing Polysomnography

In the current research, a predominance of males was noted among individuals undergoing polysomnography, with 64.41% identified as male and 35.59% as female. This distribution of sex corresponds with existing literature that highlights a greater incidence of obstructive sleep apnea (OSA) in males relative to females. Epidemiological investigations have indicated that variations in anatomy, hormonal levels, and fat distribution play a role in this difference, as men are more prone to experience upper airway collapsibility during sleep (Young et al., 2002). Furthermore, women diagnosed with OSA may exhibit non-traditional symptoms such as insomnia or fatigue instead of the typical indicators like loud snoring, which could result in underdiagnosis. The male dominance observed in our study group suggests both a higher biological vulnerability and potentially increased clinical awareness

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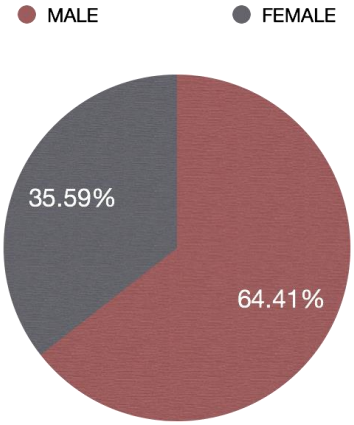
that leads to referrals for diagnostic evaluation. (Shown in figure-7)



N= 38 **N=21**

Figure 7: Sex distribution in the study population.

For every individual in the study, the eGFR was shown at different : levels of chronic kidney disease (CKD). The eGFR for the EARLY CKD patients was 43.95 ± 9.90 mL/min/1.73 m², significantly higher than for the LATE CKD patients, whose mean eGFR was 20.60 ± 3.64 mL/min/1.73 m². As seen in the table, the t-value was 10.696 and the p-value was 0.000 ($p < 0.001$), strongly showing that there was a noticeable decrease in renal function as CKD advanced.(See table-2) This decrease in eGFR from early to late stages matches what is known about CKD, as losing more nephrons makes the kidneys less able to filter efficiently. The observations support what has been noticed before, that eGFR is an important measure of kidney function and disease severity (Levey et al., 2009). For doctors, this indicates why finding and managing CKD early is important, as lower kidney function over time means a higher chance of heart problems and death (Go et al., 2004). Monitoring eGFR at all times plays a crucial role in treating and forecasting CKD which means saving kidney function should be a top priority at the beginning of the disease.

Table 2: eGFR between the groups of the study population.

Group Statistics	GROUP	Mean ± Std. Deviation	t (Sig.) – value
eGFR	**EARLYCKD**	**43.948±**	**10.696**
		9.902	**(0.000*)**
	LATECKD	**20.595± 3.644**	

Assessment of Hemoglobin Levels in the Two Cohorts

Hemoglobin levels were assessed in the study population to determine anemia status, taking into account gender differences. The average hemoglobin concentration was 8.58 ± 0.72 mg/dL. Statistical analysis indicated a t-value of 1.067, suggesting no significant difference in hemoglobin levels between the groups categorized by gender. Anemia is a prevalent complication among patients with chronic kidney disease (CKD), frequently arising from reduced erythropoietin production along with other contributing factors such as iron deficiency and inflammation (Babitt & Lin, 2012). (Shown in figure-The hemoglobin values observed indicate moderate anemia, aligning with findings in CKD populations where hemoglobin levels generally decrease as kidney function worsens. Despite the absence of a significant difference between groups in this study, it remains essential to monitor hemoglobin levels, as anemia in CKD patients is linked to increased morbidity, diminished quality of life, and a heightened risk of cardiovascular events (Stauffer & Fan, 2014). (Shown in figure-8)

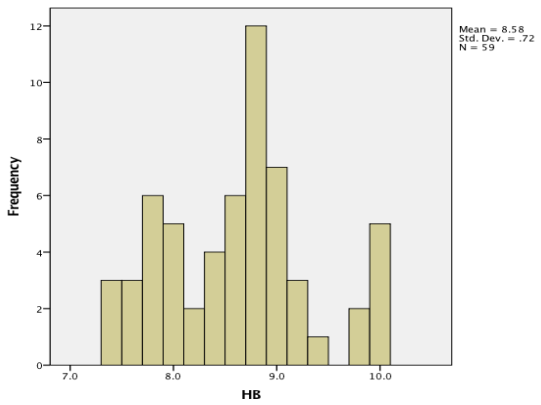


Figure 8: Haemoglobin in the study population.

Triglyceride Levels in the Study Population

The average triglyceride level within the study population was 105.4 ± 27.23 mg/dL. This figure is within the acceptable range as per current guidelines,

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which define fasting triglyceride levels under 150 mg/dL as optimal (American Heart Association, 2020).

Triglycerides are significant lipid elements that can increase cardiovascular risk when present in high levels, particularly in individuals with chronic conditions such as chronic kidney disease (CKD) or metabolic syndrome (Huang et al., 2011). The relatively normal triglyceride levels noted in this population may indicate effective lipid management or early stages of disease in certain patients. Nevertheless, consistent monitoring is crucial, as dyslipidemia, including high triglycerides, is prevalent in CKD and can worsen cardiovascular complications (Vaziri, 2016).(Shown in figure-9)

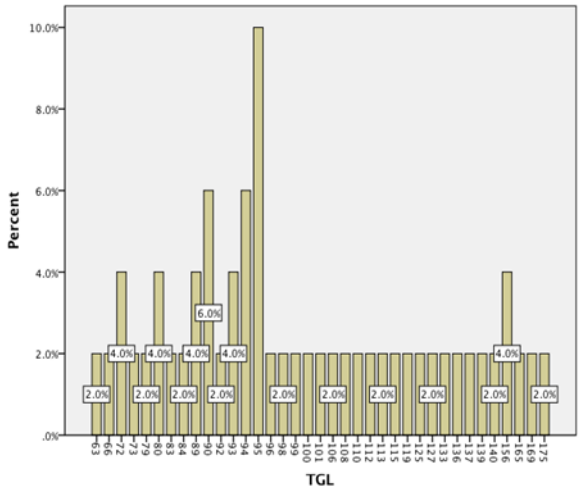

Figure 9: TGL levels in the study population.

Correlation Among the Variables:

A correlation among the variables namely the Mallampatti score, duration of CKD and the neck circumference with the AHI was done using the Pearson's correlation and the p value was set at 0.05 level. There was a positive correlation between AHI + Mallampatti score and AHI and duration of CKD. There was no significant correlation between AHI and neck circumference.(Shown in table-3)

Table 3: AHI correlation with Mallampatti score, duration of CKD, Neck circumference

	MALLAMPATTI	DURATION OF CKD	**NECK CIRCUMFERENCE**
AHI	Pearson Correlation	.435**	.280*	-.053
	Sig. (2-tailed)	.001	.032	.690
	N	59	59	59

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Apnea Hypoapnea Index In The Two Groups:

The apnea hypopnea index was calculated. Apnea hypopnea index was high in the late CKD groups compared to the early CKD group. (Table-4)

Table 4 :AHI between the early CKD and the late CKD groups

AHI * GROUP Cross tabulation			**GROUP**		**Total**
			EARLYCKD	**LATE CKD**	
AHI	**Normal 0-5**	**Count**	**6**	**1**	**7**
		%	**85.71 %**	**14.28 %**	**100.0%**
	Mild 6-15	**Count**	**14**	**1**	**15**
		%	**93.3%**	**6.7%**	**100.0%**
	Moderate 16-30	**Count**	**5**	**6**	**11**
		%	**45.45 %**	**54.54.0 %**	**100.0%**
	Severe >30	**Count**	**4**	**22**	**26**
		%	**15.38 %**	**84.61 %**	**100.0%**
Total		**Count**	**29**	**30**	**59**
		%	**49.15 %**	**50.84 %**	**100.0%**

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AHI AND ODI IN THE TWO GROUPS:

The Mann Whitney U-test statistic was applied, it is observed that there is statistical significance ($p<0.05$) between Early and Late CKD with respect to AHI and ODI.(Shown in table-5)

Table 5: AHI and ODI between the two groups

	Group I Early CKD	Group II Late CKD
AHI mean SD	**19.19 +/- 23.57**	**57.99 +/- 33.04**
ODI mean SD	**27.47 +/- 31.44**	**46.27 +/- 45.49**

4. Conclusion

In this investigation involving 485 patients diagnosed with stage 2 to 4 chronic kidney disease (CKD), it was found that 15.05% were classified as high risk for obstructive sleep apnea (OSA) based on the Berlin questionnaire. Polysomnography results confirmed that 71.23% of those evaluated exhibited sleep apnea, with severe OSA being notably more common in the late CKD cohort (stage 4). Statistical analysis revealed a significant disparity in the apnea-hypopnea index (AHI) and oxygen desaturation index (ODI) between the early and late CKD groups ($p < 0.05$). These results suggest a considerable prevalence of OSA among non-dialysis stage 4 CKD patients, with the severity of OSA escalating as kidney function deteriorates. Implementing early screening for OSA in CKD patients could potentially reduce related morbidity.

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