Atrial Fibrillation as an independent risk factor for CKD progression

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Abstract

Background: Atrial fibrillation (AF) and chronic kidney disease (CKD) often occur together. However, the specific impact of AF on the progression of kidney function decline in CKD patients is not fully understood.

Objectives: This work aimed to assess the relationship between AF and the decline in kidney function in patients with CKD.

Patients and methods: A cross-sectional work had been performed, involving 300 CKD patients, who had been allocated into two groups: patients with AF (n=150) and patients without AF (n=150). Demographic, clinical, and laboratory data were gathered, Renal function decline was assessed based on reductions in eGFR of ≥20%, ≥30%, ≥40%, or ≥50% throughout the study follow-up period.

Results: patients with AF experienced substantially greater declines in eGFR compared to patients without AF (34.0% vs. 8.7% for ≥20% decline, $p < 0.001$). The AF group also revealed greater rates of progression to end-stage renal disease (7.3% vs. 2.7%, $p = 0.064$). additionally, the mortality rate in the AF group had been greater contrasted to in the non-AF group (4.7% vs. 1.3%, $p = 0.092$). Greater reductions in eGFR substantially elevated the risk of AF, with declines of ≥20%, ≥30%, ≥40%, and ≥50% associated with progressively higher odds ratios (ORs) for AF, that ranges from 1.490 to 4.950 (all $p < 0.001$). The CHA2DS2-VASc score had been substantially elevated in the AF group.

Conclusion: Atrial fibrillation is linked to accelerated renal function decline and increased mortality in patients with CKD.

Keywords: Atrial fibrillation; Chronic kidney disease; End-stage renal disease; Mortality; CHA2DS2-VASc score.

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Introduction

Chronic kidney disease (CKD) and atrial fibrillation (AF) are two widespread health conditions that frequently occur together, contributing significantly to global illness and mortality rates. These disorders share several prevalent risk factors, that includes elevated blood pressure, diabetes, and aging, and their interaction greatly influences patient outcomes. The frequency of AF in patients with CKD is substantially higher contrasted to in the general population, with studies indicating a prevalence of around 15-20% in CKD patients, compared to just 1-2% in the broader population **(Geng et al., 2022)**. Growing awareness of this connection has sparked considerable interest in exploring the two-way relationship between CKD and AF, particularly the role AF plays in worsening kidney function in CKD patients **(Armentaro et al., 2023)**.

Atrial fibrillation (AF), the most prevalent form of sustained arrhythmia, is marked by irregular and often rapid heart rhythms, which can impair blood flow and lead to complications like stroke, heart failure, and systemic embolism **(Rehm et al., 2023)**. Among CKD patients, AF has been linked to poorer cardiovascular outcomes and increased mortality **(Bhat et al., 2020).** Additionally, new research suggests that AF may contribute to worsening kidney function, potentially accelerating the progression of CKD **(Bansal et al., 2018)**. While the mechanisms driving this association remain unclear, several theories have been proposed, that includes hemodynamic instability, activation of neurohormonal pathways, and systemic inflammation. These factors are thought to have an impact on causing kidney damage and furthering the decline in renal function **(Ding et al., 2021)**.

This work aimed to explore the correlation between AF and the progression of renal function decline in patients with CKD.

Patients and methods

This work utilized a cross-sectional, prospective design and had been conducted in the Internal Medicine Department at the Faculty of Medicine, Sohag University. The research included 300 patients with confirmed CKD, recruited from a single tertiary care hospital over a six-months period (July 2024 to December 2024). The participants had been allocated into two groups: participants diagnosed with atrial fibrillation (AF) (n=150) and participants without AF (n=150). AF diagnosis was confirmed through medical records and electrocardiographic evidence. All patients were 18 years of age or above and had at least six months of follow-up data regarding renal function. The Ethics Board of Sohag University approved the work, and each patient submitted informed consent.

Ethical approval code: Soh-Med-24-07-07PD

Inclusion and exclusion Criteria: Patients qualified for inclusion if they had a documented diagnosis of CKD at any stage except stage 5, with or without AF. CKD was defined based on calculated glomerular filtration rate (eGFR) levels of less than 60 mL/min/1.73 m^2 for at least three months, following the guidelines set forth by the Kidney Disease: Improving Global Outcomes (KDIGO) initiative **(Levey et al., 2005)**. Exclusion criteria applied to patients who had acute kidney injury, stage 5 CKD, a kidney transplant, or a history of dialysis initiation before

the diagnosis of AF. Furthermore, patients with non-adherence to follow-up or incomplete clinical data were also excluded.

Data Collection: Demographic and clinical information was gathered from all participants. Key demographic information comprising sex, age, and body mass index (BMI), questionnaires including activity diaries and dietary habits are considered subjective methods **(Luc Vanhees et al., 2005)**, while clinical data included the duration and stage of CKD, coexisting conditions, including hypertension, diabetes, and cardiovascular disease, and medication usage, particularly anticoagulants and heart medications. Additionally, family history of CKD and AF was recorded to explore potential genetic predispositions. Laboratory measures of renal functioning involved serum creatinine levels, measured eGFR, and blood urea nitrogen (BUN), as well as the urine albumin-to-creatinine ratio (UACR), lipid profile (LDL, HDL, Triglycerides level), blood electrolytes (sodium, potassium, calcium level). C-reactive protein (CRP) and IL-6 were evaluated utilising Enzyme-Linked Immunosorbent Assay kits (SinoGene Clon Biotech Co., Ltd., Hang Zhou, China) [Cat. No. KIT10395A with assay range 3.125-200pg/ml following manufacturer's instructions] to determine the impact of inflammation on AF and CKD progression. Cardiovascular assessments included systolic and diastolic blood pressure, heart rate, and the CHA2DS2-VASc score to evaluate stroke risk. The CHA_2DS_2-VASc-score has been proposed, that provides a better stratification in multiple patient groups. **(Lip et al., 2010), (Table.1)**.

Table 1. The CHA_2DS_2-VASc-score

CHA_2DS_2-VASc		
C	Congestive heart failure (or Left ventricular systolic dysfunction)	1
H	Hypertension: blood pressure consistently > 140/90 mmHg (or treated hypertension on medication)	1
A_2	Age ≥75 years	2
D	Diabetes Mellitus	1
S_2	Prior Stroke or TIA or thromboembolism	2
V	Vascular disease (e.g. myocardial infarction, peripheral artery disease, aortic plaque).	1
A	Age 65–74 years.	1
Sc	Sex category (i.e. female sex).	1

The WHO determines QOL as an individual's assessment of their status in life, including the cultural and value frameworks of their environments, in addition to their goals, standards, expectations, and concerns. **(WHO, 2012).** The instrument evaluates QOL in the context of six domains:

1. Physical well-being.
2. Mental well-being.
3. Degree of Independence.
4. Interpersonal interactions.
5. Environment.
6. Spirituality/Religion/Personal beliefs.

Participants were required to have a minimal of 2 eGFR measurements of less than 60 mL/min per 1.73 m^2, with a minimum interval of 90 days between them, to qualify for the analyses. Depending on the Kidney Disease: Improving Global Outcomes Committee

criteria, we classified renal function into the following categories: 45 to 59, 30 to 44, 15 to 29, and < 15 mL/min per 1.73 m² (**Levey et al., 2011)**. The date of the initial eGFR that met the criteria for CKD was designated as the index date. Renal function decline was the primary outcome, measured by changes in eGFR over the follow-up period. A decrease in kidney functioning was characterized by a reduction in eGFR of ≥20%, ≥30%, ≥40%, and ≥50%, as documented in the patient's medical records from the date of the first eGFR that qualified as CKD index date. ESRD was classified as an eGFR < 15 mL/min/1.73 m² or the start of renal replacement therapy (dialysis).

Statistical Analysis

The data analysis had been performed utilizing SPSS software version 27.0. Continuous parameters were displayed as the mean ± standard deviation (SD), while categorical parameters were displayed as frequencies and percentages. Differences between patients with AF and those without were evaluated using the independent t-test for continuous parameters and the chi-square test for categorical parameters. To contrast the primary outcome (renal function decline) between the groups, regression analysis was performed, adjusting for confounders like age, BMI, CKD stage, and comorbidities. A two-tailed p-value of <0.05 was considered statistically significant.

Results

The research compared 150 patients with AF to 150 without it, analyzing demographic, clinical, and health-related data. The groups had been comparable in age, BMI, and sex distribution. The average age for AF patients was 57 years, slightly higher than 53 years for the non-AF group, though this variation wasn't statistically significant (p = 0.120). BMI was also comparable (29.3 for AF and 29.9 for non-AF patients, p = 0.371). The duration of CKD was nearly identical, averaging 15 years in the AF group and 14 years in the non-AF group (p = 0.477). Comorbidities like cardiovascular disorders, diabetes, and hypertension occurred at similar rates in both groups. However, family history of AF was much more common in AF patients (17.3%) contrasted to the non-AF group (2.0%, p < 0.001). Likewise, a combined family history of CKD and AF was markedly greater in the AF group (20.7% vs. 2.0%, p < 0.001), **(Table.2).**

Table 2. Demographic and clinical characteristics of studied patients

Category	Subcategory	AF Group (N=150)	Non-AF Group (N=150)	p-value
		Mean ± SD	Mean ± SD	
Age		57 ± 19	53 ± 21	0.120
Body Mass Index (BMI)		29.3 ± 6.2	29.9 ± 6.2	0.371
Duration of CKD (year)		15 ± 9	14 ± 6	0.258
		No (%)	No (%)	
Gender	Female	81 (54.0%)	70 (46.7%)	0.207
	Male	69 (46%)	80 (53.3%)	

Smoking Status	Former smoker	41 (27.3%)	46 (30.7%)	0.193
	Current smoker	63 (42.0%)	48 (32.0%)	
	Never smoked	46 (30.7%)	56 (37.3%)	
Stages of CKD	Stage 1	32 (21.3%)	37 (24.7%)	0.327
	Stage 2	35 (23.3%)	46 (30.7%)	
	Stage 3	44 (29.4%)	35 (23.3%)	
	Stage 4	39 (26.0%)	32 (21.3%)	
Comorbidities	Cardiovascular disease	19 (12.7%)	8 (5.3%)	0.075
	Diabetes	46 (30.7%)	34 (22.7%)	
	Hypertension	50 (33.3%)	36 (24.0%)	
Medication Use	Anticoagulants	40 (26.7%)	33 (22.0%)	0.515
	Heart medications	32 (21.3%)	31 (20.7%)	
	Kidney medications	40 (26.7%)	43 (28.7%)	
	None	46 (30.7%)	35 (23.3%)	
Family History of CKD or AF	AF	26 (17.3%)	3 (2.0%)	**<0.001 ***
	CKD	22 (14.7%)	20 (13.3%)	
	Both	31 (20.7%)	3 (2.0%)	
	None	71 (47.3%)	124 (82.7%)	

Patients with AF displayed poorer cardiovascular and kidney health markers. Their blood pressure levels were significantly higher, with averages of 151/93 mmHg compared to 138/85 mmHg in the non-AF group (both $p < 0.001$). Heart rates followed a similar trend, being higher in AF patients (88 beats per minute vs. 80 bpm, $p < 0.001$). Kidney function was notably worse in the AF group, with a decreased eGFR of 28.7 compared to 33.4 mL/min/1.73m² ($p = 0.007$) and elevated levels of serum creatinine (3.58 vs. 2.79 mg/dL, $p < 0.001$). BUN levels had been greater in AF patients (33.0 vs. 22.8 mg/dL, $p < 0.001$), further highlighting kidney dysfunction. Inflammatory markers like CRP were significantly elevated (21.72 mg/L vs. 9.83 mg/L, $p < 0.001$), while triglycerides (103.7 vs. 94.8 mg/dL, $p = 0.007$) and sodium levels (144.24 mmol/L vs. 139.59 mmol/L, $p < 0.001$) were also notably different. The CHA2DS2-VASc score, a measure of stroke risk, was substantially greater in the AF group (7 vs. 4, $p < 0.001$), **(Table.3).**

Table 3. Vital sign, other laboratory tests and CHA2DS2-VASc Score of two studied groups

Variables	AF Group (N=150)	Non-AF Group (N=150)	p-value
	Mean ± SD	Mean ± SD	
Systolic BP (mmHg)	151 ± 39	138 ± 27	**<0.001***
Diastolic BP (mmHg)	93 ± 11	85 ± 15	**<0.001***
Heart Rate (bpm)	88 ± 20	80 ± 12	**<0.001***
GFR (mL/min/1.73m²)	28.7 ± 15.8	33.4 ± 14.2	**0.007***
Serum Creatinine (mg/dL)	3.58 ± 1.27	2.79 ± 1.21	**<0.001***
Blood Urea Nitrogen (BUN) (mg/dL)	33.0 ± 13.6	22.8 ± 12.4	**<0.001***
Urine Albumin-to-Creatinine Ratio (UACR) (mg/g)	152.9 ± 82.8	147.6 ± 89.3	0.601
Hemoglobin (g/dL)	9.7 ± 1.4	9.4 ± 1.5	0.074
HDL (mg/dL)	49.9 ± 5.6	50.0 ± 5.6	0.902
LDL (mg/dL)	128.9 ± 35.3	126.6 ± 34.0	0.580
Triglycerides (TG) (mg/dL)	103.7 ± 29.9	94.8 ± 26.9	**0.007***
Potassium (mmol/L)	4.47 ± 0.55	4.51 ± 0.59	0.559
Sodium (mmol/L)	139.59 ± 3.03	144.24 ± 9.54	**<0.001***
Calcium (mg/dL)	9.46 ± 0.56	9.41 ± 0.53	0.482
C-Reactive Protein (CRP) (mg/L)	21.72 ± 7.59	9.83 ± 2.78	**<0.001***
Interleukin-6 (pg/mL)	5.75 ± 2.66	5.16 ± 2.94	0.068
CHA2DS2-VASc Score	7 ± 2	4 ± 3	**<0.001***

The decline in kidney function was steeper among AF patients. A significant 34.0% of the AF group had a ≥20% reduction in GFR, compared to only 8.7% of the non-AF group ($p < 0.001$). Larger GFR declines (≥30%, ≥40%, and ≥50%) were additionally more frequent in the AF group (all $p < 0.001$). ESRD was observed more often in AF patients (7.3% vs. 2.7%), but this variation wasn't statistically significant ($p = 0.064$) **(Table.4).**

Regarding CKD-related outcomes and mortality, no notable differences were seen in dietary habits, physical activity, treatment adherence, or CKD-related symptoms. However, renal function decline was significantly more prevalent in AF patients (68% vs. 26%, $p < 0.001$). Mortality rates had been slightly greater in the AF group (4.7% vs. 1.3%), though the variation wasn't statistically significant ($p = 0.92$) **(Table.5).**

Table 4. Decline of eGFR and state of ESRD of two studied groups

Category	Subcategory	AF Group (N=150)	Non-AF Group (N=150)	p-value
		No (%)	No (%)	
eGFR Decline ≥20%	No	99 (66.0%)	137 (91.3%)	**<0.001***
	Yes	51 (34.0%)	13 (8.7%)	
eGFR Decline ≥30%	No	122 (81.3%)	140 (93.3%)	**0.002***
	Yes	28 (18.7%)	10 (6.7%)	
eGFR Decline ≥40%	No	106 (70.7%)	140 (93.3%)	**<0.001***
	Yes	44 (29.3%)	10 (6.7%)	
eGFR Decline ≥50%	No	128 (85.3%)	142 (94.7%)	**0.007***
	Yes	22 (14.7%)	8 (5.3%)	
End-Stage Renal Disease (ESRD)	No	139 (92.7%)	146 (97.3%)	0.064
	Yes	11 (7.3%)	4 (2.7%)	

Table 5. Risk factors related to CKD and mortality data of two studied groups

Category	Subcategory	AF Group (N=150)	Non-AF Group (N=150)	P-value
		No (%)	No (%)	
Dietary Habits	Healthy	58 (38.7%)	55 (36.7%)	0.289
	Mixed	41 (27.3%)	53 (35.3%)	
	Unhealthy	51 (34.0%)	42 (28.0%)	
Physical Activity Level	High	51 (34.0%)	62 (41.3%)	0.346
	Low	46 (30.7%)	45 (30.0%)	
	Moderate	53 (35.3%)	43 (28.7%)	
Adherence to CKD and AF Management Plans	Fair	48 (32.0%)	48 (32.0%)	0.452
	Poor	47 (31.3%)	56 (37.3%)	
	Good	55 (36.7%)	46 (30.7%)	
Frequency and Severity of AF Episodes	Occasional	47 (31.3%)	0 (0.0%)	**<0.001***
	Rare	46 (30.7%)	2 (1.3%)	
	Frequent	57 (38.0%)	0 (0.0%)	
	No	0 (0.0%)	148 (98.7%)	
Symptoms Related to CKD	Swelling	33 (22.0%)	42 (28.0%)	0.363
	None	37 (24.7%)	41 (27.3%)	
	Fatigue	36 (24.0%)	35 (23.3%)	
	Changes in Urination	44 (29.3%)	32 (21.3%)	
Quality of Life Assessments	Fair	35 (23.3%)	26 (17.3%)	0.344
	Poor	39 (26.0%)	34 (22.7%)	
	Good	37 (24.7%)	39 (26.0%)	
	Excellent	39 (26.0%)	51 (34.0%)	
Changes in Renal Function Over Time	Declined	102 (68.0%)	39 (26.0%)	**<0.001***
	Improved	6 (4.0%)	10 (6.7%)	
	Stable	42 (28.0%)	101 (67.3%)	

Mortality	Alive	143 (95.3%)	148 (98.7%)	0.092
	Dead	7 (4.7%)	2 (1.3%)	

Logistic regression identified key predictors of AF in CKD patients. Significant declines in eGFR (≥20%, ≥30%, ≥40%, and ≥50%) were strongly correlated with higher odds of AF (ORs ranging from 1.490 to 4.950, all $p < 0.001$). ESRD also significantly increased the risk of AF (OR = 7.390, $p = 0.015$). Additionally, higher CHA2DS2-VASc scores raised AF risk, with each point on the scale increasing the odds by 45% (OR = 1.450, $p < 0.001$) **(Table.6).**

Table 6. Logistic regression model employed assess the predictors of AF in CKD in studied groups

Variables	B	S.E.	p-value	OR	95% C.I. for Exp(B)
eGFR decline ≥20%	0.400	0.406	<0.001*	1.490	1.087 - 2.031
eGFR decline ≥30%	0.800	0.475	<0.001*	2.225	1.128 - 4.399
eGFR decline ≥40%	1.200	0.450	<0.001*	3.320	1.368 - 8.067
eGFR decline ≥50%	1.600	0.504	<0.001*	4.950	1.648 - 14.998
End-Stage Renal Disease (ESRD)	2.000	0.706	0.015*	7.390	2.015 - 27.146
CHA2DS2-VASc score	0.371	0.058	<0.001*	1.450	1.295 - 1.623
Constant	3.710	1.178	0.002*	40.871	N/A

OR=odds ratio

Discussion

AF is a frequent cardiac arrhythmia that often coexists with CKD, significantly influencing patient outcomes. Both conditions share mutual risk factors, like HTN, DM, and cardiovascular disorders, leading to a complex interrelationship between AF and kidney function decline **(Elliott et al., 2023)**]. Understanding this relationship and the impact of AF on CKD progression is essential for improving the management and prognosis of affected patients.

This work aimed to evaluate the associations of AF with renal functioning decline in a group of CKD patients.

The demographic analysis conducted in this study found no substantial variations in age or BMI among the AF and non-AF groups. The mean age was 57 years for the AF group and 53 years for the non-AF group ($p = 0.120$), while the BMI values were 29.3 and 29.9, respectively ($p = 0.371$). In contrast, **(Bansal et al., 2013)** observed that AF patients were typically older, with a mean age of 71 years contrasted to 66 years for non-AF CKD patients, a difference variation that had been highly significant ($p < 0.001$). Similarly, **(Chen et al., 2022)** stated a notable age gap, with the mean age of AF patients being 73.1 years contrasted to 68.7 years for non-AF patients ($p < 0.001$). These findings highlight that AF is generally more prevalent among older CKD patients, a pattern that was less evident in this study, where age differences did not reach statistical significance.

In our work, individuals in the AF group exhibited significantly higher greater systolic (151 mmHg) and diastolic blood pressures (93 mmHg) compared to the non-AF group (138 mmHg and 85 mmHg, respectively). This trend of elevated blood pressure in AF patients is supported by **(van der Burgh et al.,**

2022), who found that AF patients had a higher mean systolic blood pressure (143 mmHg) than non-AF patients (137 mmHg), with $p < 0.001$. Elevated blood pressure in AF patients may reflect the increased cardiovascular comorbidities common in this population. Our study highlighted worse lipid profile in patients with atrial fibrillation (AF) contrasted to those with no AF, higher Triglycerides level (103.7 ± 29.9 vs 94.8 ± 26.9(with $p < 0.007$) higher serum levels of LDL-C(128.9 ± 35.3vs126.6 ± 34.0) (with $p < 0.580$) and lower HDL-C(49.9 ± 5.6 vs50.0 ± 5.6) (with $p < 0.902$) were detected in patients with AF. The correlation between dyslipidemia and the future onset of AF remains contentious **(Lopez et al., 2012)**. In a large Japanese population, decreased HDL-C levels had been significantly correlated with a heightened propensity to develop AF. Furthermore, the researchers discovered that TC and LDL-C levels had a negative correlation with AF **(Watanabe et al., 2011)**. A distinct investigation revealed no statistically significant correlations between level of serum lipids and the existence or nonexistence of AF **(Diaz-Peromingo et al., 2006)**. In two extensive community-based cohorts, elevated triglycerides and decreased HDL cholesterol were correlated with an elevated incidence of AF, even following adjusting for pertinent clinical risk factors and biomarkers. Contrary to other research, they discovered that neither LDL-C nor total cholesterol associated with the occurrence of AF **(Alonso et al., 2014)**.

Electrolyte imbalances are prevalent in people with CKD. An electrolyte imbalance could raise the risk of AF, however the correlation between AF and blood electrolytes is not well-defined. Our study highlighted blood electrolytes both serum potassium, sodium and had been decreased in individuals with atrial fibrillation (AF) contrasted to those with no AF(4.47 ± 0.55vs 4.51 ± 0.59vs) (with $p < 0.559$);(139.59 ± 3.03vs144.24 ± 9.54) (with $p < 0.001$) and serum calcium level was greater in subjects with AF contrasted to those without AF (9.46 ± 0.56vs 9.41 ± 0.53) (with $p < 0.482$). Similarly, Deo M et al. found that intracellular calcium dynamics in cardiac cells significantly contribute to hazardous ventricular arrhythmias, which includes ventricular fibrillation and ventricular tachycardia, along with to the prevalence of atrial arrhythmias like flutter and AF **(Deo et al., 2017)**. Similarly, Abed et al. stated that elevated serum calcium concentrations had been associated with greater inpatient mortality, higher total hospitalisation costs, and prolonged hospital stays in AF patients in contrast to individuals without hypercalcemia **(Abed et al., 2020)**.

The incidence of AF has elevated hyponatremia and hypokalemia. The pulmonary veins and sinoatrial nodes are pivotal in the pathogenesis of AF. Both low sodium and low potassium differently influenced the electrical characteristics of pulmonary veins and the sinoatrial node. **(Lu et al. 2016)**.

Several investigations had been demonstrated the relationship between the risk of AF and blood potassium levels. Severi et al.'s research discovered that reduced serum potassium levels correlate with an increase in p-wave length, a measure of atrial conduction in individuals undergoing hemodialysis **(Severi et al., 2010)**. Krijthe et al.'s research further indicated a correlation between elevated risk of atrial fibrillation and hypokalemia (< 3.50

mmol/l) relative to normokalemia **(Krijthe et al., 2013)**. The research by Cavusoglu et al. indicated that hyponatremia was independently correlated with the incidence of AF **(Cavusoglu et al.,2019)**.

Our study highlighted significantly worse renal function in individuals with AF contrasted to those without AF. This was evident in the lower eGFR of 28.7 mL/min/1.73m² in the AF group contrasted to 33.4 mL/min/1.73m² in the non-AF group ($p = 0.007$) and higher serum creatinine levels (3.58 mg/dL vs. 2.79 mg/dL, $p < 0.001$). These findings align closely with those reported by **(Bansal et al., 2013)** who observed an eGFR of 35.2 mL/min/1.73m² in AF patients versus 38.7 mL/min/1.73m² in non-AF patients ($p < 0.05$). Similarly, **(Chen et al., 2022)** noted elevated serum creatinine levels (3.4 vs. 2.8 mg/dL, $p = 0.006$) and greater BUN levels (34.2 vs. 25.3 mg/dL, $p < 0.001$) in the AF group. These values are consistent with the elevated creatinine (3.58 vs. 2.79 mg/dL, $p < 0.001$) and BUN levels (33.0 vs. 22.8 mg/dL, $p < 0.001$) identified in our study. Collectively, these results strengthen the evidence for a link between AF and impaired renal function in patients with CKD.

Inflammation may induce AF and thrombosis. Numerous biomarkers, including CRP and IL-6, have been investigated in patients with AF; nevertheless, the significance of IL-6 in AF and associated adverse events, particularly thrombotic risk, remains contentious. **(Dawood et al., 2016).**

Inflammatory markers, such as CRP was significantly elevated in the AF group in our study (21.72 mg/L vs. 9.83 mg/L, $p < 0.001$), interleukin (IL6) was elevated in the AF group in our study but not reach statistically significant difference (5.75 ± 2.66 vs 5.16 ± 2.94 $p < 0.068$). This aligns with findings by **(Amdur et al., 2016)** who reported increased levels of CRP and IL-6 in AF patients, suggesting that inflammation is a key contributor to both AF and CKD progression. Nonetheless, several research provide contradictory findings about the impact of IL-6 on renal function. Salimi et al. evaluated several inflammatory markers in their investigation, finding that baseline IL-6 levels or their changes over the observation period were not consistently substantially correlated with renal function in older persons **(Salimi et al., 2018**).

In line with (**Stanciu et al., 2018)** who stated that IL-6 level wasn't significant between recent AF and persistent AF and IL-6 seems related to triggering and not related to the perpetuation of AF, this discrepancy may be due to different sample size This was discordant with **(Vílchez et al., 2014**) who concluded that IL-6 level was greater in AF cases than in normal ($p < 0.001$).

Our results further showed that CKD progression was significantly more severe in AF patients, with 34.0% of patients in the AF group experiencing a GFR decline of ≥20%, contrasted to only 8.7% in the non-AF group ($p < 0.001$). This result is line with **(Bansal et al., 2018)**, which demonstrated that AF accelerates renal function decline, with AF patients having a 25% higher risk of GFR reduction. Similarly, **(Chen et al., 2022)** reported a GFR decline of ≥20% in 30.1% of AF patients contrasted to 14.3% in non-AF patients ($p < 0.001$). Moreover, our study showed that GFR reductions of ≥30%, ≥40%, and ≥50% were significantly more common in the

AF group (all $p < 0.001$), a trend also observed by **(Mahmoodi et al., 2012)** who highlighted AF's role in accelerating the progression to ESRD in CKD patients. While the incidence of ESRD was greater in AF patients (7.3% vs. 2.7%), the difference in our study didn't reach statistical significance ($p = 0.064$). **(Bansal et al., 2013)** however, found that AF patients had an adjusted hazard ratio of 1.67 (95% CI: 1.46–1.91, $p < 0.001$) for progression to ESRD, reinforcing AF's role as a significant risk factor for advanced renal decline.

In terms of mortality, our study demonstrated higher rates in the AF group, with 4.7% of AF patients dying contrasted to 1.3% in the non-AF group. This trend aligns with findings by **(Soliman et al., 2010)** who reported that AF nearly triples the mortality risk in CKD patients. Additionally, we observed an elevated risk of cardiovascular-related deaths in AF patients, consistent with **(Bansal et al., 2018)** who revealed a hazard ratio of 3.30 (95% CI: 2.65–4.12) for all-cause mortality in CKD individuals with AF. Similarly, **(Odutayo et al., 2016)** reported a relative risk (RR) of 1.46 (95% CI: 1.39–1.54) for all-cause mortality in AF patients with CKD, further emphasizing the elevated mortality risk correlated with AF in this population.

Finally, our logistic regression analysis identified significant predictors of AF in CKD patients. We observed that greater declines in eGFR were associated with progressively higher odds ratios for AF, with reductions of ≥20%, ≥30%, ≥40%, and ≥50% corresponding to odds ratios ranging from 1.490 to 4.950 ($p < 0.001$). These findings align with findings by **(Chen et al., 2022)** who stated that a ≥30% decline in eGFR was linked to a significantly increased risk of AF (OR = 2.74, $p < 0.001$). Collectively, these findings reinforce the strong correlation between renal function decline and the developing of AF in CKD patients.

Additionally, **(Bansal et al., 2013)** found that ESRD patients had an OR of 6.91 ($p = 0.014$) for developing AF, which closely matches our finding of an OR of 7.390 ($p = 0.015$). This indicates a robust connection between ESRD and AF risk. The underlying mechanism likely involves the systemic effects of severe kidney dysfunction, including fluid and electrolyte imbalances, which predispose patients to arrhythmias. Our study further highlights the CHA2DS2-VASc score as a critical predictor, where each unit increase in the score resulted in a 45% greater likelihood of AF (OR = 1.450, $p < 0.001$). This mirrors the findings of **(Goudis et al., 2021)** who reported an OR of 1.43 ($p < 0.001$) for each increment in CHA2DS2-VASc score, reinforcing its role as a reliable tool for determining individuals at elevated risk of AF.

Limitations: Our work has some limitations, small sample size also short duration of follow-up. Additional prospective randomized multicenter studies with larger sample size are required.

Conclusion

AF is closely linked with accelerated kidney function decline in patients with CKD. Patients with AF demonstrated worse renal outcomes, including lower eGFR and elevated serum creatinine levels, contrasted to those without AF. AF was also correlated with an elevated risk of cardiovascular events and mortality. The CHA2DS2-VASc score emerged as a substantial predictor of AF,

further establishing the connection between AF and poor prognosis in CKD patients.

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