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Frequency of Atrial Fibrillation in Patients with Hypokalemia

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ABSTRACT

Background: Atrial fibrillation (AF) is one of the most common cardiac arrhythmias and is associated with increased morbidity and mortality. Electrolyte disturbances, particularly hypokalemia, can alter cardiac electrical activity and may contribute to the development of arrhythmias. Identifying factors associated with atrial fibrillation in patients with hypokalemia may help improve prevention and management strategies. **Methods:** This cross-sectional study included 245 participants. Demographic, clinical, and lifestyle characteristics were collected and analyzed. Variables examined included age, gender, residence status, diabetes mellitus, hypertension, dyslipidemia, smoking status, and socioeconomic status. The relationship between these factors and the presence of atrial fibrillation was evaluated using statistical analysis, with $p < 0.05$ considered statistically significant. **Results:** Among the 245 participants, 77 (31.4%) were diagnosed with atrial fibrillation. Most participants were aged 61–80 years (68.6%), and the gender distribution was nearly equal. Significant associations were observed between atrial fibrillation and residence status ($p = 0.01$), hypertension ($p = 0.01$), dyslipidemia ($p = 0.01$), smoking ($p = 0.01$), and socioeconomic status ($p = 0.01$). In contrast, age ($p = 0.78$), gender ($p = 0.78$), and diabetes mellitus ($p = 0.11$) were not significantly associated with atrial fibrillation. **Conclusion:** Atrial fibrillation was present in nearly one-third of the study population. The findings suggest that cardiovascular risk factors and lifestyle characteristics may play an important role in the occurrence of atrial fibrillation among patients with hypokalemia.

INTRODUCTION

Atrial fibrillation is the most common sustained cardiac arrhythmia.[1] Atrial fibrillation is associated with a 3 to 5 times higher risk of stroke and with a higher risk of heart failure, cardiac mortality, and overall mortality.[2-3] Atrial fibrillation is due to abnormal electrical activity within the atria of the heart, causing them to fibrillate.[4] Atrial fibrillation is characterized as a tachyarrhythmia, which means that the heart rate is often fast. This arrhythmia may be paroxysmal (less than seven days) or persistent (more than seven days). Due to its rhythm irregularity, blood flow through the heart becomes turbulent and has a high chance of forming a thrombus (blood clot), which can ultimately dislodge and cause a stroke.[5] Risk factors for atrial fibrillation include advanced age, high blood pressure, underlying heart and lung disease, congenital heart disease, and increased alcohol consumption.[6-7] Symptoms of atrial fibrillation vary from asymptomatic to symptoms such as chest pain, palpitations, fast heart rate, shortness of breath, nausea, dizziness, diaphoresis (severe sweating), and generalized fatigue.[8]

Potassium homeostasis plays a central role in dysrhythmias, highlighted by observational reports.[9] Hypokalemia is associated with an increased risk of cardiac arrhythmias and sudden cardiac death.[10-11] One study reported that hypokalemia was associated with an increase in P-wave duration, a marker of atrial conduction.[12] P-wave duration increase has been associated with a higher risk of atrial fibrillation.[13-14] This supports the hypothesis that serum potassium is involved in atrial conduction and possibly atrial fibrillation. A study by Saxena et al analyzing the impact and association of serum potassium levels with atrial fibrillation found that 46.0% of admitted hypokalemic patients developed atrial fibrillation.[15] Another study reported 64.6% patients having hypokalemia to have developed atrial fibrillation.[16] The Rotterdam Study in 2013 revealed that out of 474 patients who developed atrial fibrillation, patients with hypokalemia (<3.5 mmol/l) had a higher risk of atrial fibrillation (hazard ratio: 1.63, 95%CI: 1.03–2.56) than those with normokalemia (3.5–5.0 mmol/l).[17]

Hypokalemia can disrupt cardiac electrical activity and predispose patients to arrhythmias, including atrial fibrillation. The findings of this study may help in understanding the potential link between low potassium levels and the burden of atrial fibrillation. Understanding

the frequency of atrial fibrillation in patients with hypokalemia can help refine risk stratification and treatment protocols for patients with electrolyte imbalances. This knowledge could lead to better preventive measures, timely interventions, and tailored therapies that address the underlying causes of AF. This study seeks to contribute to a more comprehensive approach to managing cardiac health in patients prone to hypokalemia, enhancing overall cardiovascular care and reducing the burden of AF-related complications.

MATERIAL AND METHODS

The study was conducted in the Department of Medicine at Jinnah Postgraduate Medical Center from 22 Feb 2025 to 22 June 2025 after obtaining prior approval from the Research Evaluation Unit of the College of Physicians and Surgeons Pakistan and clearance from the Institutional Ethical Review Committee. Patients admitted during the study period were screened on a daily basis to identify those meeting the predefined inclusion and exclusion criteria. Only patients aged 45 years or above, of either gender, and having documented hypokalemia were considered eligible. Individuals with severe anemia, stage-5 chronic kidney disease, acute infections, advanced congestive heart failure (NYHA class III–IV), malignancy, autoimmune disorders, or pre-existing atrial fibrillation were excluded based on clinical evaluation and review of medical records.

After confirming eligibility, the purpose and procedures of the study were explained in detail to each patient, and written informed consent was obtained. A non-probability consecutive sampling technique was applied, and all eligible patients admitted during the study period were enrolled until the required sample size was achieved.

At enrollment, detailed demographic and baseline information was collected. Age and gender were recorded, and area of residence was categorized as urban or rural according to the operational definition. Socioeconomic status was determined based on reported monthly family income and classified into low, middle, or high categories. Height and weight were measured using standardized equipment, and body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2).

Clinical history was obtained through patient interviews and review of hospital records. The presence of diabetes mellitus was determined based on HbA1c levels greater than 6.5%, a documented prior diagnosis, or current use of antidiabetic medications. Hypertension was identified by documented blood pressure readings of systolic ≥140 mmHg and/or diastolic ≥90 mmHg, a previous diagnosis, or current use of antihypertensive drugs. Any previously diagnosed cardiac disease was also recorded from the medical records.

Laboratory investigations were reviewed to document serum potassium levels. Hypokalemia was confirmed when serum potassium was found to be below 3.5 mmol/L according to the operational definition. A resting 12-lead electrocardiogram (ECG) was performed for each participant under standardized conditions. The ECG recordings were analyzed, and any episode of atrial fibrillation lasting 30 seconds or more was identified. The diagnosis of atrial fibrillation was verified by a senior cardiologist with more than five years of post-fellowship clinical experience to ensure diagnostic accuracy and consistency.

All collected information, including demographic details, clinical findings, laboratory results, and ECG interpretations, was carefully documented on a structured and predesigned proforma. Patients continued to receive medical management according to institutional treatment protocols, and participation in the study did not interfere with standard clinical care.

RESULTS

A total of 245 participants were included in the study. Their baseline characteristics are summarized in Table 1. Most participants were in the 61–80 year age group, representing 168 individuals (68.6%), while 77 participants (31.4%) were aged 45–60 years. This indicates that the study population consisted largely of older adults, a group known to have a higher risk of atrial fibrillation. The gender distribution was almost equal, with 124 males (50.6%) and 121 females (49.4%), ensuring balanced representation of both sexes. Regarding place of residence, the majority of participants lived in urban areas (206; 84.1%), whereas 39 participants (15.9%) were from rural areas. Several comorbid conditions were also observed in the study population. Diabetes mellitus was present in 70 participants (28.6%), while 175 (71.4%) did not have diabetes. Hypertension was identified in 63 individuals (25.7%), whereas 182 participants (74.3%) had no history of hypertension. In addition, 116 participants (47.3%) were diagnosed with dyslipidemia, while 129 (52.7%) were not.

With respect to lifestyle factors, 89 participants (36.3%) reported a history of smoking, whereas 156 (63.7%) were non-smokers. Socioeconomic status varied across the study population. Fifty-nine participants (24.1%) had a monthly income of less than 35,000, 98 (40%) reported income between 35,000 and 70,000, and 88 participants (35.9%) had an income greater than 75,000.

Overall, 77 participants (31.4%) were diagnosed with atrial fibrillation, while 168 (68.6%) did not have the condition. The relationship between baseline characteristics and the presence of atrial fibrillation is presented in Table 2. Among participants aged 45–60 years, 27 individuals (35.1%) had atrial fibrillation, whereas 50 (64.9%) did not. In the 61–80 year age group, 62 participants (36.9%) had atrial fibrillation and 106 (63.1%) did not. The difference between the age groups was not statistically significant ($p = 0.78$), indicating that age was not associated with atrial fibrillation in this study.

Among male participants, 44 (35.5%) had atrial fibrillation, while 80 (64.5%) did not. Among female participants, 45 (37.2%) had atrial fibrillation and 76 (62.8%) did not. The difference between males and females was not statistically significant ($p = 0.78$). Residence status showed a significant association with atrial fibrillation. Among urban residents, 60 participants (29.1%) had atrial fibrillation, compared with 146 (70.9%) without the condition. In contrast, 29 rural

residents (74.4%) had atrial fibrillation, while only 10 (25.6%) did not. This difference was statistically significant (p = 0.01), suggesting that atrial fibrillation was more common among rural residents.

Among participants with diabetes mellitus, 20 individuals (28.6%) had atrial fibrillation and 50 (71.4%) did not. Among those without diabetes, 69 participants (39.4%) had atrial fibrillation and 106 (60.6%) did not. The association was not statistically significant (p = 0.11). A significant relationship was observed between hypertension and atrial fibrillation. Among participants with hypertension, 14 individuals (22.2%) had atrial fibrillation while 49 (77.8%) did not. Among those without hypertension, 75 participants (41.2%) had atrial fibrillation and 107 (58.8%) did not. This difference was statistically significant (p = 0.01). Dyslipidemia was also significantly associated with atrial fibrillation. Among participants with dyslipidemia, 19 individuals (16.4%) had atrial fibrillation and 97 (83.6%) did not. In contrast, among those without dyslipidemia, 70 participants (54.3%) had atrial fibrillation while 59 (45.7%) did not. This association was statistically significant (p = 0.01). Smoking was strongly associated with atrial fibrillation. Among smokers, 47 participants (52.8%) had atrial fibrillation, compared with 42 (47.2%) without the condition. Among non-smokers, 42 individuals (26.9%) had atrial fibrillation and 114 (73.1%) did not. The difference was statistically significant (p = 0.01). Socioeconomic status also showed a significant association with atrial fibrillation (p = 0.01). In the lowest income group (<35,000), 38 participants (64.4%) had atrial fibrillation compared with 21 (35.6%) who did not. In the 35,000–70,000 income group, 22 individuals (22.4%) had atrial fibrillation while 76 (77.6%) did not. Among participants with income greater than 75,000, 29 individuals (33%) had atrial fibrillation and 59 (67%) did not.

Overall, atrial fibrillation was present in 31.4% of the study population. While age, gender, and diabetes mellitus were not significantly associated with atrial fibrillation, several factors showed significant relationships. These included residence status, hypertension, dyslipidemia, smoking, and socioeconomic status. Participants from rural areas, those with hypertension, smokers, and individuals with lower socioeconomic status demonstrated a higher prevalence of atrial fibrillation. These findings suggest that both clinical risk factors and social determinants of health may contribute to the occurrence of atrial fibrillation in this population.

Table 1

Distribution of baseline characteristics among the study participants.

Variables	n (%)
Age	
45 to 60 years	77 (31.4)
61 to 80 years	168 (68.6)
Gender	
Male	124 (50.6)
Female	121 (49.4)
Residence status	
Urban	206 (84.1)
Rural	39 (15.9)
Diabetes Mellitus	
Yes	70 (28.6)
No	175 (71.4)
Hypertension	
Yes	63 (25.7)
No	182 (74.3)
Dyslipidemia	
Yes	116 (47.3)
No	129 (52.7)
Smoking status	
Yes	89 (36.3)
No	156 (63.7)
Socioeconomic status	
<35000	59 (24.1)
35000-70000	98 (40)
>75000	88 (35.9)
Atrial fibrillation	
Yes	77 (31.4)
No	168 (68.6)
Total	245 (100)

Table 2

Distribution of patient characteristics according to the Atrial fibrillation groups.

Variables	Atrial fibrillation Yes n (%)	Atrial fibrillation No n (%)	P value
Age			
45 to 60 years	27 (35.1)	50 (64.9)	0.78
61 to 80 years	62 (36.9)	106 (63.1)	
Gender			
Male	44 (35.5)	80 (64.5)	0.78
Female	45 (37.2)	76 (62.8)	
Residence status			
Urban	60 (29.1)	146 (70.9)	0.01
Rural	29 (74.4)	10 (25.6)	
Diabetes Mellitus			0.11
Yes	20 (28.6)	50 (71.4)	
No	69 (39.4)	106 (60.6)	
Hypertension			
Yes	14 (22.2)	49 (77.8)	0.01
No	75 (41.2)	107 (58.8)	
Dyslipidemia			
Yes	19 (16.4)	97 (83.6)	0.01
No	70 (54.3)	59 (45.7)	
Smoking status			
Yes	47 (52.8)	42 (47.2)	0.01
No	42 (26.9)	114 (73.1)	
Socioeconomic status			
<35000	38 (64.4)	21 (35.6)	0.01
35000-70000	22 (22.4)	76 (77.6)	
>75000	29 (33)	59 (67)	

DISCUSSION

This study examined the frequency of atrial fibrillation (AF) and its association with demographic, clinical, and lifestyle factors among patients with hypokalemia. AF was identified in 31.4% of participants, suggesting a considerable burden of arrhythmia in this patient population. Several variables; particularly residence status, hypertension, dyslipidemia, smoking, and socioeconomic status; showed significant associations with AF, whereas age, gender, and diabetes mellitus were not significantly related to its occurrence.

In the present study, nearly one-third of participants were diagnosed with atrial fibrillation. This relatively high proportion may reflect the known arrhythmogenic effects of electrolyte disturbances, particularly low serum potassium levels. Hypokalemia alters cardiac membrane potentials and electrical conduction, which can increase susceptibility to arrhythmias.

These findings are consistent with previous research. Farah et al. [21] reported that hypokalemia was significantly associated with a higher prevalence of atrial fibrillation among hospitalized patients. [21] Similarly, a population-based cohort study conducted by Krijthe et al. found that individuals with lower serum potassium levels had a higher risk of developing AF compared with those with normal potassium levels. [18] Together, these findings support the view that electrolyte imbalance is an important contributor to arrhythmia development.

Although most participants in this study were between 61 and 80 years of age, age did not show a statistically significant association with AF. This differs somewhat from previous studies that have identified advanced age as a major risk factor for atrial fibrillation. For example, Wang et al. [22] reported that AF prevalence increases markedly in older populations and that elderly patients with AF and hypokalemia may experience worse cardiovascular outcomes. The absence of a significant relationship in the current study may be related to the relatively limited age variation among participants, as most were already in older age groups.

Gender was also not significantly associated with AF in this study. The proportions of males and females with atrial fibrillation were similar. This observation aligns with findings reported by Phillips et al. [20], who noted that although electrolyte disturbances increase the risk of arrhythmias, gender differences often become less pronounced once other clinical factors are considered. [20]

Residence status showed a significant relationship with atrial fibrillation, with rural residents experiencing a higher prevalence of AF compared with those living in urban areas. This pattern may reflect differences in healthcare access, early detection of cardiovascular conditions, and preventive health practices. Individuals living in rural areas may face barriers to specialized healthcare services, which could delay diagnosis and management of conditions that predispose patients to arrhythmias.

Hypertension was significantly associated with atrial fibrillation in this study. This finding is consistent with existing literature that identifies hypertension as a key risk factor for AF. Elevated blood pressure contributes to structural changes in the atria, including fibrosis and atrial enlargement, which can disrupt normal electrical conduction.

Similar results were reported by Farah et al. [21] who observed a higher prevalence of hypertension among patients with atrial fibrillation compared with those without AF. Likewise, Krijthe et al. [18] highlighted that cardiovascular risk factors such as hypertension may interact with electrolyte disturbances to increase the likelihood of AF development.

Dyslipidemia also demonstrated a significant association with atrial fibrillation. Abnormal lipid levels contribute to atherosclerosis, vascular inflammation, and endothelial dysfunction, all of which may indirectly affect atrial structure and function. These mechanisms may increase vulnerability to atrial arrhythmias. The findings emphasize the importance of addressing lipid abnormalities as part of comprehensive cardiovascular risk management.

Smoking was another factor significantly associated with atrial fibrillation in this study. Participants who smoked had a noticeably higher prevalence of AF compared with non-smokers. Smoking contributes to oxidative stress, systemic inflammation, and autonomic imbalance, which may promote arrhythmogenesis. This observation is supported by the findings of Phillips et al. [20], who reported that patients with electrolyte disturbances; particularly hypokalemia; may face an increased risk of arrhythmias when additional risk factors such as smoking are present.

Socioeconomic status also showed a significant relationship with atrial fibrillation. Participants with lower income levels were more likely to have AF. Socioeconomic factors can influence several determinants of cardiovascular health, including access to medical care, health literacy, and lifestyle habits. Limited access to preventive services and early treatment may increase the risk of developing cardiovascular complications such as atrial fibrillation.

The findings of this study highlight the complex interplay between electrolyte imbalance, cardiovascular risk factors, and social determinants of health in the development of atrial fibrillation. While hypokalemia remains an important contributor to arrhythmogenesis, other factors; including hypertension, smoking, and socioeconomic conditions; may further influence the risk of AF.

Previous research also suggests that correcting electrolyte disturbances may improve clinical outcomes. For example, Cacioppo et al. [19] reported that administration of potassium and magnesium was associated with a higher probability of spontaneous conversion to sinus rhythm in patients presenting with atrial fibrillation in emergency settings. [19] These findings highlight the importance of careful electrolyte monitoring and management in patients at risk of arrhythmias.

From an epidemiological perspective, the findings of this study can be understood within the framework that most diseases arise from the interaction of several contributing factors rather than a single cause. In this study, atrial fibrillation was associated with hypertension, dyslipidemia, smoking, rural residence, and lower socioeconomic status, suggesting that multiple exposures may act together to influence the risk of arrhythmia. As described by Rothman, Huybrechts, and Murray, many diseases develop through a multifactorial causal process in which different component causes combine to produce a health outcome. In this context, hypokalemia may represent one contributing factor, while cardiovascular comorbidities and lifestyle-related exposures may further increase susceptibility to atrial fibrillation. Considering these results through an epidemiological lens helps explain why the occurrence of atrial fibrillation in this population appears to reflect the combined influence of clinical, behavioral, and social factors.[23]

Overall, atrial fibrillation was identified in nearly one-third of the study population. The analysis revealed significant associations between AF and several factors, including residence status, hypertension, dyslipidemia, smoking, and socioeconomic status. These results underscore the importance of addressing both clinical risk

factors and broader social determinants when developing strategies to prevent and manage atrial fibrillation in patients with electrolyte disturbances.

LIMITATIONS

This study has several limitations that should be considered when interpreting the findings. The cross-sectional design does not allow conclusions about causality, and the relatively small sample drawn from a single population may limit the generalizability of the results to other settings.

CONCLUSION

Atrial fibrillation was present in nearly one-third of the study population and showed significant associations with hypertension, dyslipidemia, smoking, residence status, and socioeconomic level. These findings highlight the need to consider both clinical risk factors and social determinants when addressing atrial fibrillation among patients with hypokalemia.

REFERENCES

1. Trohman, R. G., Huang, H. D., & Sharma, P. S. (2023). Atrial fibrillation: Primary prevention, secondary prevention, and prevention of thromboembolic complications: Part 2. *Frontiers in Cardiovascular Medicine*, *9*. https://doi.org/10.3389/fcvm.2022.1060096
2. Bordignon, S., Chiara Corti, M., & Bilato, C. (2012). Atrial Fibrillation Associated with Heart Failure, Stroke and Mortality. *Journal of Atrial Fibrillation*, *5*(1), 467. https://doi.org/10.4022/jafib.467
3. Singleton, M. J., Imtiaz-Ahmad, M., Kamel, H., O'Neal, W. T., Judd, S. E., Howard, V. J., Howard, G., Soliman, E. Z., & Bhave, P. D. (2020). Association of atrial fibrillation without cardiovascular comorbidities and stroke risk: From the regards study. *Journal of the American Heart Association*, *9*(12). https://doi.org/10.1161/jaha.120.016380
4. Leventopoulos, G., Koros, R., Travlos, C., Perperis, A., Chronopoulos, P., Tsoni, E., Koufou, E., Papageorgiou, A., Apostolos, A., Kaouris, P., Davlouros, P., & Tsigkas, G. (2023). Mechanisms of atrial fibrillation: How our knowledge affects clinical practice. *Life*, *13*(6), 1260. https://doi.org/10.3390/life13061260
5. Pellman, J., & Sheikh, F. (2015). Atrial fibrillation: Mechanisms, therapeutics, and future directions. *Comprehensive Physiology*, 649-665. https://doi.org/10.1002/cphy.c140047
6. Aune, D., Mahamat-Saleh, Y., Kobeissi, E., Feng, T., Heath, A. K., & Janszky, I. (2023). Blood pressure, hypertension and the risk of atrial fibrillation: A systematic review and meta-analysis of cohort studies. *European Journal of Epidemiology*, *38*(2), 145-178. https://doi.org/10.1007/s10654-022-00914-0
7. Lee, S. H., Park, S., Byeon, K., On, Y. K., Kim, J. S., Shin, D., Cho, J. G., Kim, Y., & Kim, Y. (2013). Risk factors between patients with lone and non-lone atrial fibrillation. *Journal of Korean Medical Science*, *28*(8), 1174. https://doi.org/10.3346/jkms.2013.28.8.1174
8. Rienstra, M., Lubitz, S. A., Mahida, S., Magnani, J. W., Fontes, J. D., Sinner, M. F., Van Gelder, I. C., Ellinor, P. T., & Benjamin, E. J. (2012). Symptoms and functional status of patients with atrial fibrillation. *Circulation*, *125*(23), 2933-2943. https://doi.org/10.1161/circulationaha.111.069450
9. Thu Kyaw, M., & Maung, Z. M. (2022). Hypokalemia-induced arrhythmia: A case series and literature review. *Cureus*. https://doi.org/10.7759/cureus.22940
10. Macdonald, J. E., & Struthers, A. D. (2004). What is the optimal serum potassium level in cardiovascular patients? *Journal of the American College of Cardiology*, *43*(2), 155-161. https://doi.org/10.1016/j.jacc.2003.06.021
11. Scirica, B. M., & Morrow, D. A. (2012). Potassium concentration and repletion in patients with acute myocardial infarction. *JAMA*, *307*(2), 195. https://doi.org/10.1001/jama.2011.2003
12. Severi, S., Pogliani, D., Fantini, G., Fabbrini, P., Viganò, M. R., Galbiati, E., Bonforte, G., Vincenti, A., Stella, A., & Genovesi, S. (2010). Alterations of atrial electrophysiology induced by electrolyte variations: Combined computational and P-wave analysis. *EP Europace*, *12*(6), 842-849. https://doi.org/10.1093/europace/euq042
13. Maheshwari, A., Norby, F. L., Soliman, E. Z., Alraies, M. C., Adabag, S., O'Neal, W. T., Alonso, A., & Chen, L. Y. (2017). Relation of prolonged P-wave duration to risk of sudden cardiac death in the general population (from the atherosclerosis risk in communities study). *The American Journal of Cardiology*, *119*(9), 1302-1306. https://doi.org/10.1016/j.amjcard.2017.01.012
14. Rasmussen, M. U., Kumarathurai, P., Fabricius-Bjerre, A., Larsen, B. S., Domínguez, H., Davidsen, U., Gerds, T. A., Kanters, J. K., & Sajadieh, A. (2020). P-wave indices as predictors of atrial fibrillation. *Annals of Noninvasive Electrocardiology*, *25*(5). https://doi.org/10.1111/anec.12751
15. Saxena, N., Saxena, S., & Mathew, C. (2020). Study of impact and association of Serum Potassium Levels with the incidence of risk of Atrial Fibrillation. *Int Arch Integr Med*, *7*(2), 12. https://www.iaimjournal.com/wp-content/uploads/2020/02/iaim_2020_0702_01.pdf
16. Saxena, N., Saxena, S., & Mathew, C. (2020). Study of impact and association of Serum Potassium Levels with the incidence of risk of Atrial Fibrillation. *Int Arch Integr Med*, *7*(2), 12. https://www.iaimjournal.com/wp-content/uploads/2020/02/iaim_2020_0702_01.pdf
17. Krijthe, B. P., Heeringa, J., Kors, J. A., Hofman, A., Franco, O. H., Witteman, J. C., & Stricker, B. H. (2013). Serum potassium levels and the risk of atrial fibrillation. *International Journal of Cardiology*, *168*(6), 5411-5415. https://doi.org/10.1016/j.ijcard.2013.08.048
18. Krijthe, B. P., Heeringa, J., Kors, J. A., Hofman, A., Franco, O. H., Witteman, J. C., & Stricker, B. H. (2013). Serum potassium levels and the risk of atrial fibrillation. *International Journal of Cardiology*, *168*(6), 5411-5415. https://doi.org/10.1016/j.ijcard.2013.08.048
19. Cacioppo, F., Reisenbauer, D., Herkner, H., Oppenauer, J., Schuetz, N., Niederdoeckl, J., Schnaubelt, S., Gupta, S., Lutnik, M., Simon, A., Spiel, A. O., Buchtele, N., Domanovits, H., Laggner, A. N., & Schwameis, M. (2022). Association of intravenous potassium and magnesium administration with spontaneous conversion of atrial fibrillation and atrial flutter in the emergency department. *JAMA Network Open*, *5*(10), e2237234. https://doi.org/10.1001/jamanetworkopen.2022.37234
20. Phillips, C. T., Wang, J., Celi, L. A., Zhang, Z., & Feng, M. (2019). Association of hypokalemia with an increased risk

for medically treated arrhythmias. *PLOS ONE*, *14*(6), e0217432. https://doi.org/10.1371/journal.pone.0217432

21. Farah, R., Nassar, M., Aboraya, B., & Nseir, W. (2020). Low serum potassium levels are associated with the risk of atrial fibrillation. *Acta Cardiologica*, *76*(8), 887-890. https://doi.org/10.1080/00015385.2020.1799573
22. Wang, X., Wang, Y., Liu, J., Yao, J., Zhang, J., & Zhang, Y. (2023). Prognosis of older adult patients suffering from atrial fibrillation and Hypokalemia. *Clinical Interventions in Aging*, *18*, 1363-1371. https://doi.org/10.2147/cia.s422801
23. Rothman, K. J., Huybrechts, K. F., & Murray, E. J. (2024). Epidemiology. https://doi.org/10.1093/oso/9780197751541.001.0001