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Clinical Features and Results of Elderly Patients with Hyperkalemia in the Emergency Department

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Abstract

Background and Objective: The elderly population is prone to electrolyte disorders such as potassium imbalance due to physiological changes. Rapid recognition of these patients in the emergency department (ED) and detection of risk factors are important as they prevent mortality and morbidity. In this study, clinical results and risk factors of elderly patients who have been diagnosed with hyperkalemia at the ED were investigated.

Methods: This retrospective study was carried out with patients who applied to the Department of Emergency Medicine within one year. The study included patients 65 years of age and older with blood potassium levels above 5.5 mEq/L. The control group consisted of patients over 65 years of age with normal blood potassium levels. The laboratory parameters and clinical characteristics of the patients were recorded in the study form.

Results: Of the patients included in the study, 186 (51.1%) were male and 178 (48.9%) were female. Chronic kidney disease (CKD), heart failure (HF) and acute kidney injury (AKI) were significantly higher in the patient groups. The use of non-steroid anti-inflammatory drugs (NSAIDs) and spironolactone was statistically significant in the patient group. The independent risk factors for hyperkalemia were CKD (Odds Ratio [OR]: 16,377), AKI (OR: 11,261) and spironolactone use (OR:5.845), respectively.

Conclusıon: In elderly patients admitted to the

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emergency department, chronic kidney disease, acute kidney injury, heart failure, spironolactone use and the presence of multiple comorbid diseases increase the risk of hyperkalemia. Therefore, early diagnosis and implementation of treatment strategies for hyperkalemia in these patients is critical to prevent potential cardiac complications.

Keywords: Emergency department; hyperkalemia; elderly patient

INTRODUCTION

Hyperkalemia is a serious life-threatening electrolyte disorder. It is reported that there is a significant relationship between hyperkalemia and morbidity and mortality in the elderly (1). Hyperkalemia is a significant health issue in elderly individuals presenting to the emergency department. The incidence of hyperkalemia in the elderly population is generally higher compared to other age groups. This is related to factors such as the decline in kidney function with age, the presence of various chronic diseases, and the use of medications. The primary causes of hyperkalemia include kidney diseases, cardiovascular disorders, endocrine abnormalities, and the medications being used (2,3).

Several studies have shown that the prevalence of hyperkalemia is more common in the elderly, with 2-5% of patients presenting to the emergency department being diagnosed with hyperkalemia. In elderly patients, especially those aged 65 and older, the incidence of hyperkalemia increases significantly. Many studies have found that hyperkalemia in older individuals is often associated with chronic kidney disease (CKD), diabetes, hypertension, heart failure, and the use of antihypertensive medications, particularly potassium-sparing diuretics and ACE inhibitors (4,5).

The elderly population is prone to electrolyte disturbances such as potassium imbalance due to physiological changes. Potassium secretion may decrease due to diseases such as heart failure, hypertension, chronic and acute kidney ınjury which may occur more frequently in the elderly. In addition, polypharmacy, which can cause electrolyte disturbances such as hyperkalemia, is thought to occur due to the increased number of comorbidities (5). The use of drugs that may cause hyperkalemia in the presence of renal failure may be another risk factor for hyperkalemia(6). Although there are publications in the literature about hyperkalemia in the emergency department, there are limited studies on elderly patients.

In this study, we aimed to investigate the clinical outcomes and risk factors of hyperkalemia in elderly patients.

METHODS

Patients and study design

In our study, patients aged 65 years and over who had a serum K+ greater than 5.5 mEq / L who were admitted to the ED, between 01/01/2017 and 31/12/2017 were included. The study was performed retrospectively by scanning the hospital electronic medical information system. The study was approved by Ethics Committee of Clinical Researches (No. 78017789)

The cases included in the study were divided into two groups: the patient group was composed of patients over 65 years of age with high serum potassium levels, and the control group was composed of patients over 65 years of age with normal serum potassium levels.

Exclusion criteria: Pseudohyperkalemia, intravascular hemolysis, severe thrombocytosis

(number of thrombocyte>1.000.000), severe leukocytosis (leukocyte>70.000/mL), transfusion reaction, sickle cell anemia, hemolytic anemia induced with drugs, patients under the age of 65 and patients whose laboratory data are missing.

Patients with hyperkalemia were evaluated for underlying etiology and the presence of comorbid diseases such as diabetes mellitus, hypertension, acute-chronic kidney disease, and chronic heart failure were investigated. In addition, the use of non-steroidal anti-inflammatory drugs (NSAIDs), angiotensin converting enzyme inhibitors (ACEI), angiotensin receptor blockers (ARB), spironolactone, beta blockers, and the use of drugs that can cause hyperkalemia were recorded. Hemodialysis, length of hospital stay, duration of ED, number of comorbid diseases were evaluated and its relationship with serum potassium level was investigated. Risk analysis was performed for drugs and diseases causing hyperkalemia.

Systolic blood pressure(SBP), diastolic blood pressure (DBP) and pulse rate and laboratory findings (Glucose, blood urea nitrogen, creatinine, sodium, potassium, pH, pCO2, pO2, HCO3) of each patient were recorded.

Laboratory examination

During the one-year period when the study data were analyzed, no kit and autoanalyser changes were made in the central biochemistry laboratory. Since the normal range of serum potassium measuring device used by the Biochemistry Laboratory of our hospital was determined as 3.5-5.5 mEq / L, serum potassium results other than these values were included in the study. Values of 5.5mEq / L and above were evaluated as hyperkalemia.

Statistical analysis

The normality controls of continuous measurements were tested with the Shapiro Wilk test. Continuous measurements were tested by Student t test in patient control comparisons. The homogeneity of the variances was tested with One Way, ANOVA when the controls were met, and the Welch test when not. Bonferrroni and Games Howell tests were used in paired comparisons. Mean and standard deviation values were used as descriptive statistics. Pearson chi-square test was used for differences between categorical variables. Number and percentage values were used as descriptive statistics. All independent variables were included in the model and risk factors were determined by Binary Logistic regression analysis using retrospective stepwise method. The relationship between all continuous measurements was tested with Pearson correlation coefficient. Statistical significance was taken as $p < 0.005$.

RESULTS

There were 7041 patients over 65 years of age admitted to the ED and 620 of these patients had hyperkalemia. 336 cases were excluded from the study by applying exclusion criteria and 364 patients were included in the study.

When laboratory parameters are compared between patient and control groups; blood potassium, urea, creatinine, pH, HCO3 and SpO2 values were statistically significant in the patient group ($p < 0.05$) . There were no significant differences between two groups regarding diastolic blood pressure, systolic blood pressure and heart rate (Table 1).

kidney disease (CKD), heart failure (HF) and acute kidney injury (AKI) were statistically significant compared to the control group. CKD was observed in 54.9%, HF in 23.9% and AKI in 16.3% of the patients. Although DM and HT were higher than the control group, the difference was not statistically significant.

Logistic regression analysis results indicate

Table 1. Comparison of laboratory and demographic data of patient and control group

Variables	Patient	Control	p
Potassium, mEq/L	6,169 ± 0,663	4,363 ± 0,531	**<0,001**
Sodium mmol/L	136,67 ± 7,47	137,89±4,70	**0,002**
Glucose	161,41±89,20	153,97±89,22	0,611
BUN, mg/dl	128,27±65,98	47,70±25,92	**<0,001**
Creatinine, mg/dl	3,790±2,69	1,10±0,79	**<0,001**
pH	7,296±0,132	7,38±0,06	**<0,001**
HCO_3	17,630±4,361	22,79±3,3	**<0,001**
SpO2, mmHg	72,47±20,77	86,05±13,51	**<0,001**
PCO_2,mmHg	36,496±12,59	38,26±8,52	**0,021**
LS, hours	7,74±6,05	5,06±3,98	**<0,001**
SBP, mmHg	133,08±31,86	133,79±19,7	0,544
DBP, mmHg	74,54±20,19	76,39±12,65	0,317
Pulse	80,87±22,07	82,29±19,32	0,778

BUN: blood urea nitrogen; HCO3: bicarbonate; LS: Length of stay, SBP: systolic bloodpressure; DBP: diastolic blood pressure

When the distribution of drugs causing hyperkalemia between patient and control group were compared; NSAIDs and spironolactone use were statistically significant in the patient groups. ACEI, ARB and beta blocker use did not differ between the patient and control group. Chronic

several significant risk factors for hyperkalemia, each with a corresponding odds ratio (OR) that quantifies the strength of association between the risk factor and the likelihood of developing hyperkalemia. Here's a breakdown of the findings: **Chronic Kidney Disease (CKD)**: The

odds ratio of 16.377 suggests that individuals with CKD are over 16 times more likely to develop hyperkalemia compared to those without CKD. This strong association underscores the importance of monitoring potassium levels in patients with CKD. **Acute Kidney Injury (AKI)**: With an odds ratio of 11.261, AKI is also a significant risk factor. Patients experiencing AKI are more than 11 times as likely to develop hyperkalemia, highlighting the critical need for careful management of potassium in these patients as well. **Use of Spironolactone**: An OR of 5.845 indicates that patients taking spironolactone, a potassium-sparing diuretic, have nearly 6 times the odds of hyperkalemia compared to those not on this medication. This finding is important for clinicians to consider when prescribing spironolactone, especially in patients with existing kidney issues. **Presence of Two Comorbid Diseases**: The odds ratio of 4.648 suggests that patients with two comorbid conditions have a significantly increased risk (almost 5 times) of developing hyperkalemia. This points to the compounded impact of multiple health issues on potassium levels. **Presence of Three Comorbid Diseases**: An even higher odds ratio of 12.101 for patients with three comorbid conditions indicates that the risk is more than 12 times greater than those without these additional health issues. This emphasizes the need for comprehensive management of patients with multiple comorbidities to prevent hyperkalemia (Table 2).

Table 2. Independent risk factors for hyperkalemia

Parameters	**OR**	**[% 95 CI]**
CKD	16,377	[8,718-30,765]
AKI	11,261	[3,620-35,035]
Spironolakton	5,845	[1,820-18,775]
Two comorbid diseases	4.648	[2.287-9.444]
Three comorbid diseases	12.101	[5.422-27.005]

CKD: chronic kidney disease AKI: acute kidney injury OR: odds ratio CI:confidence interval

In table 3, the effect of the coexistence of two existing diseases on the risk of hyperkalemia is analyzed. The combination of CKD and HT increases the risk of hyperkalemia by 7.619 times, while the combination of CKD and DM increafses this risk by 4.974 times. The coexistence of CKD and HF raises the risk by 4.772 times. Additionally, when HT and DM accompany HF, the risk of hyperkalemia increases by 2.143 and 2.429 times, respectively.

Table 3. Risk analysis for two existing diseases

Diseases	OR	[% 95 CI]
CKD+HT	7,619	(3,849-15,081)
CKD+DM	4.974	(2,479-9,980)
CKD+HF	4,772	(1,914-11,896)
HF+HT	2,143	(1,110-4,136)
HF+DM	2,429	(1,121-5,261)

CKD: chronic kidney disease HT: hypertension

DM: diabetes mellitus HF: heart failure CI: confidence İnterval, OR: odds ratio

These findings highlight the impact of these disease combinations on hyperkalemia risk. Patients with hyperkalemia were diagnosed with glucose + insulin infusion, nebulized albuterol and bicarbonate in the ED. In addition, calcium gluconate was given to patients with ECG changes to ensure cardiac stability. Dialysis was performed in 41 patients (22.3%) with hyperkalemia resistant to medical treatment in the patient group. In the control group, dialysis was applied in only 5(2.8%) patients ($p < 0.001$)

DISCUSSION

Among the important results of this study; the presence of CKD, HF and AKI was significantly higher in the patient group. Although DM and HT were higher in the patient group compared to the control group, the difference was not statistically significant. The use of NSAIDs and spironolactone was significantly higher in the patient group. When the risk factors affecting the disease are determined; CKD, AKI, and use of spironolactone were found to be independent risk factors. The presence of two comorbid diseases increases the risk of hyperkalemia by 4.648 times and the presence of three comorbid diseases increases by 12.101 times.

Drug-induced hyperkalemia is a major cause of increased potassium levels in clinical practice. Drugs can cause hyperkalemia with various mechanisms (7). It may be related to the widespread use of drugs such as ACEI, ARB, NSAIDs, spironolactone, and the number of comorbidities that may cause hyperkalemia in the elderly. Mukete et al. reported that increased comorbid diseases in patients older than 65 years may cause polypharmacy (8). NSAIDs are the most commonly used analgesics worldwide (9). They favor hyperkalemia by disrupting renal potassium excretion (10). In a study by JP and colleagues was found that the use of NSAID alone was not associated with the development of hyperkalemia (11). In the study of Turgutalp et al. NSAIDS drug use was found to be an

independent factor for the development of hyperkalemia (12). Spironolactone can cause hyperkalemia in the distal nephron by inhibiting the binding of aldosterone to the receptor and inhibiting Na-K ATPase enzyme activity. The effect of spironolactone-induced hyperkalemia is dose-dependent and as the daily dose of spironolactone increases, the incidence of hyperkalemia increases (13). Noise et al. reported that spironolactone use causes drug-induced hyperkalemia as the second most common after ACEI (14). ARB reduces the production of angiotensin 2. It is rare in patients without risk factors despite hyperkalemia associated with ARB (15). Elgendy et al. performed a meta-analysis of 113,386 patients older than 65 years and concluded that ARBs are risk factors for the development of hyperkalemia (16). β blockers increase the entry of β adrenergic stimulus into the K + cell. On the other hand, β adrenergic blockade increases K + serum level. The increase in serum potassium is generally less than 0.5 meq / L with beta blocker treatment. True hyperkalemia is rare unless there is a large potassium burden, a marked exercise or additional potassium uptake that prevents the excretion of excess extracellular potassium, such as hypoaldosteronism or renal failure (17). Perazella MA et al. in their study found the incidence of hyperkalemia due to the use of beta blockers as 1-5% (18). In our study, NSAIDS and spironolactone use were statistically significant in the patient group compared to the control group. ACEI, ARB and beta blocker use did not differ between the patient and control groups. In addition, we found that spironolactone use was 5.8-fold independent of the risk of hyperkalemia. In the logistic analysis, we found that the use of combined drugs increased the risk of hyperkalemia more. In elderly patients, the use of multidrug with increasing age will increase the risk of hyperkalemia, so clinicians need to be more careful when writing combined medications. Preventing or minimizing concomitant treatment with drugs may prevent the risk of hyperkalemia

HT, CKD, DM and HF are potential predisposing risk factors for hyperkalemia. The risk of hyperkalemia associated with renin-angiotensin-aldosterone system (RAAS) inhibition was found to be 2-10% in patients with HT, HF and CK. RAAS plays a key role in regulating cardiac, vascular, and renal function by controlling vascular tone and salt and water balance. RAAS consists of renin, angiotensin II, and aldosterone, which increase blood pressure in response to low kidney blood flow and salt delivery. Blocking excessive RAAS activation with medications improves outcomes in cardiovascular and renal diseases (19). Turgutalp et al. in their study concluded that NSAIDs, spironolactone, ACEI, ARB, beta blockers, more than 2 comorbid disease and renal failure are independent risk factors that cause hyperkalemia (20). In a study of 1038 patients with CKD by Moranne et al., the prevalence of hyperkalemia was found to be 2% in the group with GFR> 60 ml / min / 1.73 m² and 42% in the group with GFR <20 ml / min / 1.73

m². Serum potassium abnormalities are common in CKD patients and hyperkalemia is a well-known complication of CKD with a prevalence of 14-20% (21). The incidence of hyperkalemia in diabetic patients is higher than in the general population (22). Elderly patients may have decreased renal function without significant increase in serum creatinine levels (<1.2 mg / dL). As a result, diabetic patients (especially the elderly) on medications known to interfere with homeostasis of potassium are at greater risk for hyperkalemia (23,24). Thomsen et al. reported that in one of six newly diagnosed diabetic patients, one in six people had severe clinical outcomes and death-related hyperkalemic events. They also reported that the risk of hyperkalemia would be more common in patients with DM and CKD (25). HF affects approximately 37 million adults worldwide and is the leading cause of hospitalization and death (26). It is a source of concern and may be a life-threatening condition in HF patients (27). A dynamic relationship between heart and kidney dysfunction cardiorenal syndrome with evidence of CKD has been identified in more than half of HF patients (28). Besides, many drugs used to treat HF in general have been found to cause hyperkalemia (29). In their study, Thomsen et al. reported that 4 out of 10 patients with HF developed hyperkalemia as well as decreased renal function and spironolactone use as a strong risk factor in these patients. In the same study, the presence of chronic renal failure with HF was found to be a risk factor for the development of hyperkalemia (30). In our study, CKD, HF and AKI were significantly higher in the patient group. CKD was observed in 54.9%, HF in 23.9% and AKI in 16.3% of the patients. Although the DM and HT patients were higher than the control group, the difference was not statistically significant. When risk analysis is made for the existing diseases; risk for CKD + HT, CKD + DM and CKD + HF was respectively 7.6, 4.9 and 4.7. Patients aged 65 years and older, especially those presenting to the emergency department, are at higher risk due to various health conditions. Conditions affecting renal function, such as chronic kidney disease (CKD) and acute kidney injury (AKI), may increase the likelihood of hyperkalemia in these patients. The use of potassium-sparing diuretics such as spironolactone may also increase this risk, especially in patients with multiple comorbidities. It is vital for clinics to be alert to the risk of hyperkalemia in patients in this age group and to monitor renal function and potassium levels during the treatment process to prevent serious cardiac complications. In this context, patients' treatment plans should be meticulously evaluated, potassium levels should be regularly monitored and drug interactions should be considered.

Hyperkalemia may cause fatal ventricular tachycardia, ventricular fibrillation, atrioventricular block and asystole. Khanagavi et al. found that hyperkalemia and mortality duration were simultaneously associated with hospitalized patients with serum potassium> 5.1 meq / L(31). Noize et al. reported the mortality

rate due to hyperkalemia as 9.8% (14). An et al. found a high rate of arrhythmia (35.2%) and cardiac arrest (43.3%) in patients with serum potassium levels > 6.5 meq / L (32). In the study performed by Thomsan et al. the 6-month mortality rate after hyperkalemia was found to be 20%. Mortality rate was 6.47 compared with matched individuals without hyperkalemia (25). In our study, mortality due to hyperkalemia was found to be 22 (12%) and 7 (3.9%) without hyperkalemia.

Glucose + insulin infusion, nebulized albuterol and bicarbonate were started in the ED. In addition, calcium gluconate was given to patients with ECG changes to ensure cardiac stability. Dialysis was performed in 41 patients (22.3%) with hyperkalemia resistant to medical treatment in the patient group. In the control group, dialysis treatment was performed in only 5 (2.8%) patients. The length of stay in the emergency department was longer in the patient groups than in the control group.

The fact that our study was performed in a single center based on retrospective records with a small number of patient populations is a significant limitation.

CONCLUSIONS

In elderly patients admitted to the emergency department, chronic kidney disease, acute kidney injury, heart failure, spironolactone use and the presence of multiple comorbid diseases increase the risk of hyperkalemia. Hyperkalemia is a significant condition in elderly individuals that can lead to serious health issues. Therefore, it is crucial for older adults to attend regular health check-ups and have their potassium levels closely monitored.

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REFERENCES

1. Borra S, Shaker R, Kleinfeld M. Hyperkalemia in an adult hospitalized population. Mt Sinai J Med 1988;55:226–229.

2. Lindner G, Burdmann EA, Clase CM, Hemmelgarn BR, Herzog CA, Małyszko J, Nagahama M, Pecoits-Filho R, Rafique Z, Rossignol P, Singer AJ. Acute hyperkalemia in the emergency department: a summary from a Kidney Disease: Improving Global Outcomes conference. Eur J Emerg Med 2020;27:329-337.

3. Singer AJ, Thode HC, Jr, Peacock WF. A retrospective study of emergency department potassium disturbances: severity, treatment, and outcomes. Clin Exp Emerg Med 2017; 4:73–79.

4. Rafique Z, Peacock F, Armstead T, Bischof JJ, Hudson J, Weir MR, Neuenschwander J. Hyperkalemia management in the emergency department: An expert panel consensus. J Am Coll Emerg Physicians Open 2021;2:e12572.

5. Schlanger LE, Bailey JL, Sands JM. Electrolytes in the aging. Adv Chronic Kidney Dis 2010;17:308–319.

6. Steinman MA, Landefeld CS, Rosenthal GE, Berthenthal D, Sen S, Kaboli PJ. Polypharmacy and prescribing quality in older people. J Am Geriatr Soc 2006;54:1516–1523.

7. Mount DB, Zandi-Nejad K. Disorders of potassium balance. In: Brenner and Rector's The Kidney, 8th ed, Brenner BM (Ed), WB Saunders Co, Philadelphia 2008.547.

8. Mukete BN, Ferdinand KC. Polypharmacy in Older Adults With Hypertension: A Comprehensive Review.J Clin Hypertens (Greenwich) 2016 ;18:10-8.

9. Green T, Gonzalez AA, Mitchell KD, Navar LG. The complex interplay between cyclooxygenase-2 and angiotensin II in regulating kidney function. Curr Opin Nephrol Hypertens 2012; 21:7.

10. Garella S, Matarese RA. Renal effects of prostaglandins and clinical adverse effects ofnonsteroidal anti-inflammatory agents. Journal Medicine 1984;63:165-181.

11. Lafrance JP, Miller DR. Dispensed selective and nonselective nonsteroidal anti-inflammatory drugs and the risk of moderate to severe hyperkalemia: a nested case-control study. Am J Kidney Dis 2012; 60:82.

12. Turgutalp K, Bardak S, Helvacı I, İşgüzar G, Payas E, Demir S, et al.Community-acquired hyperkalemia in elderly patients: risk factors and clinical outcomes. Renal Failure 2016;38:1405-1412.

13. Pitt B, Zannad F, Remme WJ, Cody R, Castaigne A, Perez A,et al. The effect of spironolactone on morbidity and mortality in patients with severe heart failure. Randomized Aldactone Evaluation Study Investigators. N Engl J Med 1999 ;341:709-17.

14. Noize P, Bagheri H, Durrieu G, Haramburu F, Moore N, Giraud P, et al. Life-threatening drug-associated hyperkalemia: a retrospective study from laboratory signals. Pharmacoepidemiol Drug Saf 2011;20:747-53.

15. Phillips CO, Kashani A, Ko DK, Francis G, Krumholz HM. Adverse effects of combination angiotensin II receptor blockers plus angiotensin-converting enzyme inhibitors for left ventricular dysfunction: a quantitative review of data from randomized clinical trials. Arch Intern Med 2007;167:1930-6.

16. Elgendy IY, Huo T, Chik V, Pepine CJ, Bavry AA. Efficacy and safety of angiotensin receptor blockers in older patients: A meta-analysis of randomized trials. Am J Hypertens 2015;28:576–585.

17. Arthur S, Greenberg A. Hyperkalemia associated with intravenous labetalol therapy for acute hypertension in renal transplant recipients. Clin Nephrol 1990; 33:269.

18. Perazella MA. Drug-induced hyperkalemia: old culprits and new offenders. Am J Med 2000;109:307-14.

19. Weir MR, Rolfe M. Potassium homeostasis and renin-angiotensin-aldosterone system Inhibitors.CJASN 2010;5:531-548.

20. Sica DA. Mineralocorticoid Receptor Antagonists for Treatment of Hypertension and Heart Failure. Methodist Debakey Cardiovasc J 2015;11: 235–39.

21. Moranne O, Froissart M, Rossert J, Gauci C, Boffa JJ, Haymann JP, et al. Timing ofonset of CKD-related metabolic complications. J Am Soc Nephrol 2009 ;20:164-71.

22. Uribarri J, Oh MS, Carroll HJ. Hyperkalemia in diabetes mellitus. J Diabet Complications 1990;4:3–7.

23. Oxlund CS, Henriksen JE, Tarnow L, Schousboe K, Gram J, Jacobsen IA. Low dose spironolactone reduces blood pressure in patients with resistant hypertension and type 2 diabetes mellitus: a double blind randomized clinical trial. J Hypertens 2013;31: 2094-102.

24. Raebel MA, Ross C, Xu S, Roblin DW, Cheetham C, Blanchette CM, et al. Diabetes and drug-associated hyperkalemia: effect of potassium monitoring. J Gen Intern Med 2010;25:326–33.

25. Thomsen RW, Nicolaisen SK, Adelborg K, Svensson E, Hasvold P, Palaka E, et al. Hyperkalaemia in people with diabetes: occurrence, risk factors and outcomes in a Danish population-based cohort study. Diabet Med 2018;35:1051-60.

26. Ziaeian B, Fonarow GC. Epidemiology and aetiology of heart failure. Nat Rev Cardiol 2016;13:368–378.

27. Conway R, Creagh D, Byrne DG, O'Riordan D, Silke B. Serum potassium levels as an outcome determinant in acute medical admissions. Clin Med (Lond) 2015;15:239–243.

28. Ahmed A, Rich MW, Sanders PW, Perry GJ, Bakris GL, Zile MR, et al. Chronic kidney disease associated mortality in diastolic versus systolic heart failure: a propensity matched study. Am J Cardiol 2007;99:393-8.

29. Yancy CW, Jessup M, Bozkurt B, Butler J, Casey DE Jr, Colvin MM, et al.2017 ACC/AHA/HFSA Focused Update of the 2013 ACCF/AHA Guideline for the Management of Heart Failure.Circulation 2017;136:137-61.

30. Thomsen RW, Nicolaisen SK, Hasvold P, Garcia-Sanchez R, Pedersen L, Adelborg K,et al. Elevated Potassium Levels in Patients With Congestive Heart Failure: Occurrence, Risk Factors, and Clinical Outcomes: A Danish Population-Based Cohort Study. J Am Heart Assoc 2018;22;7(11).

31. Khanagavi J, Gupta T, Aronow WS, Shah T, Garg J, Ahn C et al. Hyperkalemia among hospitalized patients and association between duration of hyperkalemia and outcomes. Arch Med Sci 2014;10: 251–57.

32. An JN, Lee JP, Jeon HJ, Kim DH, Oh YK, Kim YS, Lim CS. Severe hyperkalemia requiring hospitalization: predictors of mortality. Crit Care 2012;16:R22.