Potassium level changes – arrhythmia contributing factor in chronic kidney disease patients

I. A. CHECHERIŢĂ1,2), CRISTIANA DAVID1,2), V. DIACONU3), AL. CIOCÂLTEU1,2), I. LASCĂR4)

1) Department of Nephrology, Urology and Transplant Immunology, “Carol Davila” University of Medicine and Pharmacy, Bucharest
2) Department of Nephrology and Dialysis
3) Department of Cardiology “St. John” Emergency Clinical Hospital, Bucharest
4) Department of Surgical Specialties, “Carol Davila” University of Medicine and Pharmacy, Bucharest

Abstract
As the renal function progressive decline is often correlated to diuresis impairment, potassium level changes represent a major pathophysiological factor in monitoring chronic kidney disease. Even more, potassium level imbalance could lead to life-threatening situations with the risk of severe rhythm disorders appearance. The aim of the study was to determine in which degree the serum potassium changes are implicated in arrhythmias development in CKD patients.

Patients and Methods
We included 678 CKD patients (predialysis and dialysed patients) to whom we recorded biohumoral and clinical features in correlations with the possibility of arrhythmias genesis.

Results: we noticed, in our predialysis group, an important correlation between hyper-/hypokalemia and arrhythmias appearance, more frequent during hypokalemia episodes (OR=4.04, respectively OR=7.5). The same situation was observed in chronic dialysis group.

Conclusions: Hypokalemia is a stronger risk factor than hyperkalemia, but all together, any minimal changes in serum potassium levels could determine arrhythmia in CKD patients.

Keywords: potassium level, CKD, arrhythmia, therapy, outcome.

Introduction
Potassium level changes represent a major pathophysiological issue in monitoring chronic kidney disease (CKD) patients. This is easy to explain in the majority of cases, as renal function progressive decline is correlated to diuresis impairment [1, 2]. But, even in situations where there is a sufficient diuresis remnant (concomitant with nitrogenous waste products values increase) and there are no chronic electrolyte changes, diuresis ability to adapt to the demands of the acute event is deficient (acute renal ischemia and acute kidney injury by extrarenal organs) [3–5]. Any extrarenal pathology which may cause oliguria, any acute-on-chronic kidney disease and any drug therapy that lowers the glomerular filtration rate (GFR) could determine an imbalance of patient’s fluid homeostasis and could lead to major complications, sometimes life-threatening: hypokalemia or hypokalemia of different degrees, with the risk of severe rhythm disorders appearance [6, 7].

Patients and Methods
We conducted a clinical trial in which we monitored potassium level changes in different stages of CKD patients and its involvement in arrhythmias genesis. The study took over two years in CKD patients (predialysed and dialysed patients) admitted into Nephrology and Dialysis Department, “St. John” Emergency Clinical Hospital, Bucharest.

Inclusion criteria: patients with GFR below 60 mL/min./1.73 m², after three consecutive measurements within one month.

Exclusion criteria:
▪ Patients with severe chronic diseases that can major influence life expectancy and may interfere with study participation: neoplasm, severe heart or respiratory failure, uncontrolled insulin-dependent diabetes;
▪ Use of potassium supplements, steroids, digoxin, other drugs of major influence upon potassium levels;
▪ Patients who did not consented for the inclusion in the study.

The research included 678 CKD patients: 476 predialysed patients and 202 dialysed patients.

For the pre-dialysis patients we surveyed all the acute events, which required hospitalizations and noted the potassium levels every day, from the moment of admission. For dialysed patients we performed blood tests before and after a dialysis session. Twenty-four hours ECG Holter was performed for every patient and all the arrhythmias were recorded.

All data were statistic analyzed using SPSS 12.0 software and a p-value <0.05 were considered to be statistically significant.
Results

Hyper- and hypokalemia events in predialysed patients and the prevalence of arrhythmias

Quarterly we determined patients’ electrolyte values. In addition, we determined biohumoral values including electrolyte levels during any acute-on-chronic kidney disease caused by renal failure progression or by intercurrent pathological conditions, acute events manifested by oliguria and anuria.

We recorded the following data:

- Hyperkalemia transient events to 196 patients (the majority during acute-on-chronic kidney disease with oliguria and anuria) and to 29 patients sent by general practitioner or cardiologist because of increased nitrogenous waste products and serum potassium levels after angiotensin-converting enzyme (ACE) inhibitors administration. It is important to emphasize the elevated number of CKD patients under ACE inhibitors and/or angiotensin receptor blockers (ARBs) treatment that presented a hyperkalemia episode during the acute renal event (41 patients from the 61 undergoing ACE inhibitors therapy). CKD patient on ACE inhibitors treatment presents a greater risk of developing hyperkalemia during an acute-on-chronic kidney disease event.
- Persistent hyperkalemia in five patients with limited diuresis and under ACE inhibitors therapy for important proteinuria. During our study, these patients started renal replacement therapy.

- Hypokalemia events in 41 patients (most of them after diuresis resumption at the end of the acute renal episode), but also to 18 patients under excessive diuretic drug treatment, to whom serum potassium levels returned to normal after drug withdrawal or drug dose spacing.
- Persistent hypokalemia in 12 chronic tubulo-interstitial nephritis patients with salt loss and concomitant hyponatremia.

Arrhythmia in hyperkalemia

We established three groups of oliguric patients according to serum potassium levels:

1. Group A: K\(^+\) over 7.5 mEq/L – 22 cases;
2. Group B: K\(^+\) between 5 and 7.5 mEq/L – 174 cases;
3. Group C: K\(^+\) normal values – 17 cases. This group represents the patients with oliguria caused by severe digestive disorders (diarrhea, vomiting) that determine important electrolyte loss.

Within these groups, we assessed the prevalence of arrhythmias (Table 1):

<table>
<thead>
<tr>
<th>K(^+) levels</th>
<th>No. of cases</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>K(^+) &gt; 7.5 mEq/L</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>K(^+) = 5–7.5 mEq/L</td>
<td>101</td>
<td>0.58</td>
</tr>
<tr>
<td>K(^+) normal values</td>
<td>17</td>
<td>0.29</td>
</tr>
</tbody>
</table>

In Group A (K\(^+\) over 7.5 mEq/L), we could not identified any other risk factor, except hyperkalemia, for arrhythmias appearance, so we concluded the presence of hyperkalemia is sufficient for arrhythmias high prevalence.

In Group B (K\(^+\) between 5 and 7.5 mEq/L), we noticed that arrhythmias incidence was not increasing proportional with serum potassium elevated values, so arrhythmias presence might be influenced also by additional risk factors.

Arrhythmia in hypokalemia

From a total of 54 patients, with different hypokalemia values, in 41 patients (75.92%) we detected arrhythmias on electrocardiogram (ECG) and Holter monitor. We assessed 21 cases of arrhythmias in patients with serum potassium level below 3 mEq/L. Measuring OR between arrhythmias in hypokalemia groups and normal potassium level group, we established that the incidence of arrhythmias is statistic higher during hypokalemia episodes (OR=4.04).

<table>
<thead>
<tr>
<th>K(^+) values</th>
<th>No. of cases</th>
<th>%</th>
</tr>
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<tr>
<td>K(^+) &gt; 7.5 mEq/L</td>
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As hyperkalemia, hypokalemia presence is sufficient to induce arrhythmias genesis. Even more, comparing hypokalemia OR and hyperkalemia OR (ORHK/ORHK=1.87), we concluded that hypokalemia events are more arrhythmogenic.

Analyzing all potential risk factors (biohumoral and clinical features), we concluded that serum potassium values below or above normal represents the major cause in arrhythmias appearance.

We noticed that:

- For achieving 100% arrhythmogenic risk is necessary an exceeding value of 1.5 mEq/l above serum potassium normal level, and a value of 0.5 mEq/l below serum potassium normal level;
- 70.4% presented arrhythmias in hypokalemia groups and 75.92% in hypokalemia cases.

Hyper- and hypokalemia events in dialysed patients and the prevalence of arrhythmias

We recorded serum potassium values before starting dialysis session (Table 2). In the same day, for the patients included in the study, we only once assessed serum potassium levels at the end of dialysis session (Table 3). In case of arrhythmias appearance during dialysis therapy, we analyzed again serum potassium values in the precise moment we noticed ECG changes.
Table 2 – Serum potassium values before starting dialysis session

<table>
<thead>
<tr>
<th>K⁺</th>
<th>No. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;3.5 mEq/L</td>
<td>11</td>
</tr>
<tr>
<td>3.5–5 mEq/L</td>
<td>74</td>
</tr>
<tr>
<td>&gt;5 mEq/L</td>
<td>117</td>
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Table 3 – Serum potassium values at the end of dialysis session

<table>
<thead>
<tr>
<th>K⁺</th>
<th>No. of patients</th>
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<tbody>
<tr>
<td>&lt;3.5 mEq/L</td>
<td>71</td>
</tr>
<tr>
<td>3.5–5 mEq/L</td>
<td>127</td>
</tr>
<tr>
<td>&gt;5 mEq/L</td>
<td>4</td>
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</table>

Before and after dialysis session, the difference between the number of patients in hypokalemia group is caused by the fact that standard dialysis reduces intracellular potassium deposits by 30% (mostly potassium deposits are intracellular) [8, 9]. At the end of renal replacement therapy, the lesser number of patients in hyperkalemia group could be explained by:

- Inefficient dialysis – dialysis vascular access problems: the use of a single needle and blood circulation return at venous access or low flow and early disconnection for preventing blood coagulation or due to the appearance of different cardiac complications during dialysis;
- Severe hyperkalemia events at the beginning of dialysis session: hypercatabolic infectious complications, severe acidosis, hemolysis.

Before and after dialysis session, in supraventricular (SV) arrhythmias group without any clinical impact serum potassium values distribution was similar as in patients without arrhythmias (Figure 1) (there was no statistic correlation between potassium values changes and SV arrhythmias appearance).

Figure 1 – Serum potassium values distribution in supraventricular arrhythmias group and without arrhythmias group.

Discussion

In the present research, we evaluated the association of potassium level changes and the arrhythmia development in pre-dialysed and dialysed patients.

After we assessed all data, we observed that there was a statistic correlation between hypokalemia group and the prevalence of ventricular (V) arrhythmias without any clinical impact and more frequent in hypokalemia group then in hyperkalemia group (OR=2.93, respectively OR=1.05).

We noticed the same situation in V arrhythmias patients with clinical impact (OR=3.92, respectively OR=1.18).

In addition, hypokalemia represents a stronger risk factor in developing arrhythmia than hyperkalemia and it could be responsible even for sudden death [10–14].

Our results are in concordance with international studies, which have shown the importance of potassium level in arrhythmia genesis in CKD patients and concluded that hemodialysis did not influence the frequency of arrhythmias [15].

The present study also emphasized that hyperkalemia represents a major risk factor for CKD patients and it is of great importance, for preventing any additional complications, to correct this pathological condition in time [16].

Conclusions

As it would had been expected, the euvoletic patients from the initial group did not have less arrhythmias events, since a large number of them had been disconnected with hypokalemia and after 4–5
hours post-dialysis they presented arrhythmias events until serum potassium values had been normalized.

Patients with severe serum potassium levels' variations presented the most arrhythmias events. At the end of dialysis session, in hypokalemia group (71 cases), we noticed the most frequency of V arrhythmias episodes (61 cases from which 46 were clinical significant).

Summarizing all types of arrhythmias events, hypokalemia is a stronger risk factor than hyperkalemia.

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References

Corresponding author
Ionel Alexandru Checherită, University Teaching Assistant, MD, PhD, Department of Nephrology, Urology and Transplant Immunology, “Carol Davila” University of Medicine and Pharmacy, “St. John” Emergency Clinical Hospital, 13 Vitan–Bârzești Highroad, Sector 4, 042122 Bucharest, Romania; Phone +4021–334 50 75, Fax +4021–334 59 70, e-mail: fizi@yahoo.com

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