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Real-world evaluation of patiromer utilization and its effects on serum potassium in veterans with end stage kidney disease

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Abstract

Hyperkalemia (serum potassium [K+] ≥5.1) is life-threatening in patients diagnosed with end stage kidney disease (ESKD). Patiromer is approved for the treatment of hyperkalemia, although its role in hyperkalemic patients with ESKD is not well understood. This study describes real-world patiromer utilization in an ESKD population and its corresponding association with serum K+ level changes. The study population was comprised of US veterans with an outpatient dispensing of patiromer and 2 or more International Classification of Diseases diagnostic codes for ESKD. A treatment course of patiromer was defined by serial dispensing events without a 30-day gap. Patiromer utilization was described by duration, average dose, persistence, and proportion of days covered during patiromer course. Mean serum K+ values were described for baseline and 3 follow-up intervals during the 180-day follow-up period. There were 458 patients with ESKD included in the study. On average, patients had 1.24 (95% CI: 1.20–1.29) patiromer courses. Half of the population discontinued their first patiromer course within 30 days, while approximately 10% of patients remained persistent at the end of the 180-day period and 102 (22.3%) patients started a second course during the 180-day follow up period. Average serum K+ concentrations during baseline and the 3 evaluation intervals during the 180-day follow-up were 5.91 mEq/L (5.85–5.97), 4.94 mEq/L (4.86–5.03), 4.89 mEq/L (4.8–4.98) and 4.88 mEq/L (4.8–4.96). Few patients remained persistent on their initial course of patiromer at the end of follow-up, but approximately 20% of patients initiated a second treatment episode after a 30-day gap in treatment during the 180-day follow-up period. Nonetheless, average serum K+ in ESKD patients were sustainably reduced by approximately 1 mEq/L during follow-up.

Abbreviations: CDW = Corporate Data Warehouse, CI = confidence interval, ESKD = end stage kidney disease, HD = hemodialysis, ICD = International Classification of Diseases, K+ = potassium, PD = peritoneal dialysis, PDC = proportion of days covered, VHA = Veterans Health Administration, VA = veteran affairs.

Keywords: end stage kidney disease (ESKD), hyperkalemia, patiromer, potassium binders

1. Introduction

Patients diagnosed with end stage kidney disease (ESKD) are at increased risk of experiencing hyperkalemia, commonly defined as serum potassium (K+) ≥5.1 mEq/L. Hyperkalemia is a life-threatening condition that can lead to the development of cardiac arrythmias and sudden cardiac arrest if untreated.[1] Cardiovascular morbidity is increased 1.4-fold in ESKD patients receiving hemodialysis (HD) who are experiencing hyperkalemic episodes.[2,3] Multiple physiologic mechanisms are involved in K+ homeostasis; however, renal K+ excretion plays a critical role.[2] Managing hyperkalemia in patients with reduced

kidney function, including those with ESKD, presents a challenge for treating clinicians.[4] In a retrospective cohort study of US patients treated with HD, the prevalence of serum K+ events with values ≥5.5 mEq/L was 16.3 to 16.8%, and as high as 62.9% on HD days that followed a long interdialytic interval.[5]

Achieving normal K+ levels in ESKD patients has typically involved a multi-stepped approach including dietary modification to reduce K+ intake; adjusting dialysate settings; and modifying hyperkalemia-inducing medications as well as utilizing medications that reduce serum K+ concentrations.[6–10] Historically, sodium polystyrene sulfonate was the only K+ binder available for use in the US. However, use of sodium polystyrene sulfonate for hyperkalemia management has been limited by its lack of effectiveness and safety concerns.[11] The recent availability of novel K+ binders may pose a shift in the treatment paradigm by providing additional pharmacologic options.[12] In 2015, patiromer, a non-absorbed polymer that exchanges calcium for K+, was approved by the Food and Drug Administration for the treatment of hyperkalemia.[13] The effectiveness of patiromer to maintain normal K+ levels was established in chronic kidney disease 1 to 5 non-dialysis patients for up to 52 weeks.[14–17]

The role of patiromer in treating hyperkalemia in patients with ESKD is not as well understood.[3,18] Given the paucity of data, the objective of this study was to describe real-world patiromer utilization in an ESKD population and its corresponding association with serum K+ level changes using electronic health record data.

2. Materials and Methods

2.1. Population, data sources, and study design

This was an observational study of US veterans diagnosed with ESKD who were dispensed outpatient patiromer in the Veterans Health Administration (VHA). We defined the index date as the first outpatient patiromer dispensation date from a VHA pharmacy between January 1, 2016 and February 28, 2021. The study population was comprised of veterans meeting all the following criteria at their index date; age ≥18; and ≥2; International Classification of Diseases (ICD) diagnostic code entries for ESKD within 365 days pre-index from either an outpatient or inpatient visit in VHA. Baseline serum K+ value was determined using the laboratory event closest to the index date, within 91 days pre-index. The primary analysis included patients with a baseline serum K+ ≥5.1 mEq/L.

The VHA Corporate Data Warehouse (CDW) was the analytic data source used for this study. The CDW is a repository of medical, pharmacy, laboratory, and other clinical data from the VHA electronic health record, as well as other administrative data. Domains from the CDW used in this study included inpatient and outpatient encounters, outpatient pharmacy dispensing, laboratory, and vital signs domains.[19] Patiromer utilization and changes in serum K+ laboratory measurements were described in a single arm cohort design using historical data generated from routine patient care. The baseline and follow-up window were relative to individual index dates with the baseline period encompassing 365 days prior to each patient index date. The baseline period was used to assess demographic, medication, laboratory, and healthcare resource utilization. The 180-day follow-up was used to assess patiromer utilization and changes in serum K+. This study was approved by University of Utah IRB and veteran affairs (VA) Salt Lake City Healthcare System Research Service (IRB_00107072).

3. Measurement

3.1. Baseline characteristics

Baseline characteristics were captured in the 365-day baseline period. Demographic data collected include age, sex, and race/ ethnicity. Comorbid conditions, classified by ICD-9/10-CM diagnosis codes and the Health Care Cost and Utilization Project's Clinical Classification Software Refined, were identified. Medications with significance to renin-angiotensin-aldosterone system with at least ≥1 outpatient pharmacy dispensing for the 365-day baseline period were reported. We defined baseline K+ as the laboratory value within 91 days pre-index closest to patiromer index date.

3.2. Patiromer utilization

Patiromer utilization was assessed during a 180-day follow-up interval and was measured based on treatment courses and individual dispensing events. The medication history estimator was applied to pharmacy dispensing data to reconstruct patients' historical medication treatment episodes.[20] The medication history estimator implemented workflows to clean and structure data and to calculate treatment episodes (i.e., patiromer treatment courses) from outpatient dispensing data. Rules were implemented to correct errors in the data (e.g., duplicates, fills that were not released, improbable units and days' supply) and standardize the total mg dispensed with each dispensing event. We defined a patiromer treatment course as starting with an initial patiromer dispensation and ending when a treatment gap exceeded 30 days. For example, if the initial patiromer dispensation was for a 30-day supply and there was no re-dispensation within 30 days of the calculated supply end date, the treatment course was classified as terminated. In the same case, if a patiromer dispensation occurred 45 days after the calculated supply end date, this constituted a new (second) patiromer treatment course. Patients could have multiple treatment courses during the follow up period.

Measures of patiromer utilization included number of drug courses, drug persistence, daily dose, adherence defined by proportion of days covered (PDC) during a course, and courses at the end of follow-up and course duration. Prescribed daily dose was calculated by dividing the total weight of dispensed drug by the number of intended days (days supplied) while observed daily dose divided the total weight by number of days between dispensing events to account for gaps in treatment that were <30 days in length. The drug course PDC was calculated by dividing the number of days a patient had patiromer in hand by the number of days in a treatment course and multiplying by 100.[21] A treatment course was censored if a patient died during a treatment course or at the end of the 180-day follow-up period.

Utilization of patiromer was also described using VA outpatient pharmacy dispensing measures that include the average number of medication fills, average number of days' supply, number of patients with dose increase or dose decrease, average number of dispensing per patient, and cumulative grams dispensed per patient. Dose increase and decrease were dichotomous measures that included patients with at least 1 change in dose from their initial patiromer dose dispensing. Cumulative grams dispensed is the total weight of patiromer dispensed to a patient during the follow-up period. With the assumption that the unit dose packets of patiromer were not split, we calculated estimated medication schedule groups by dividing the prescribed daily dose for individual dispensing events by package strength (8.4 g, 16.8 g) which gives the proportion of the unit dose packet that is available to be consumed each day; then ranges of values were assigned to the estimated medication schedule groups. For example, if 50% of 8.4 g packet was available for daily consumption then its estimated medication schedule group was "8.4 g every other day." The estimated medication schedule groups are as follows: 8.4 g less than every other day, 8.4 g every other day, 8.4 g less than daily, 8.4 g daily, 16.8 g less than daily, 16.8 g daily and 16.8 g greater than daily. Manual review of prescription instructions was done to confirm accuracy of medication schedule groupings.

3.3. Changes in serum K+

Serum K+ concentrations were assessed during the 180-day follow-up period. The follow-up period was divided into 3 follow-up intervals consisting of days 1 to 30, 31 to 91, and 92 to 182, respectively. The K+ measurement closest to the end of each follow-up interval was compared to the baseline K+ measure. A secondary analysis that averaged all the K+ values for each patient during the baseline and follow-up intervals was included. The average values for each patient were compared between baseline and each follow-up interval. Steps taken to clean and standardize laboratory data included removal of non-numeric values, incorrect topographies, measures with evidence of gross hemolysis, and measurements where timing and frequency were consistent with inpatient care.

3.4. Statistical methods

This study provided a descriptive assessment of patiromer utilization and changes in serum K+. Mean, standard deviations, and 95% confidence intervals were used to describe baseline characteristics, patiromer utilization, and changes in serum K+. To describe group central tendencies, medians and interquartile ranges were also computed. Kaplan–Meier survival curves were used to describe patiromer course duration (i.e. persistence). Sample paired t tests were used to calculate differences between baseline and follow-up serum K+ concentrations.[22] Data processing was conducted using Microsoft SQL Server Management Studio 17.4 and descriptive statistics were computed using statistical analysis system 9.4.

4. Results

4.1. Study population

There were 3419 veteran patients identified as having a patiromer dispensing during the eligibility period between January 1, 2016 and February 28, 2021. We classified 1267 patiromer users as ESKD patients based on ICD diagnosis codes during baseline period and 649 of those patients had a serum K+ concentration drawn within 91 days of index, of which 458 had a serum K+ ≥5.1 mEq/L (Fig. 1). This study describes patiromer

measures for 458 veteran patients diagnosed with ESKD with baseline serum K+ ≥5.1 mEq/L (Figure S1, Supplemental Digital Content, http://links.lww.com/MD/I170).

Most of our population was male (97.4%) and 44.8% were of African American descent with an average age of 66.3 (95% confidence interval [CI]: 65.4–67.2). Type II diabetes (72.3%), coronary artery disease (44.8%), and congestive heart failure (49.6%) were comorbid disease states that affected the largest proportions of our population. Beta blockers, loop diuretics, insulin, and angiotensin-converting enzyme/angiotensin II receptor blocker medications were reported during baseline in 77.73%, 48.47%, 42.14% and 40.61% of the population, respectively. The majority of patients (67.9%) had 1 or more hospitalization during the baseline period with the average length of stay in days being 5.89 (95% CI: 5.22–6.56). There were 367 (80.1%) patients with 1 or more emergency department visits during the baseline period and 458 (100%) had at least 1 outpatient visit. The average number of emergency department visits and outpatient clinic visits per patient was 4.48 (95% CI: 4.07–4.89) and 84.3 (95% CI: 78.66–89.94), respectively (Table 1).

4.2. Patiromer utilization

On average, patients received 2.13 (95% CI: 1.99–2.27) dispensings of patiromer during the 180-day follow up and received an average cumulative total of 593.92 g (95% CI: 535.02–652.83). The average days supplied per dispensing was 30.83 (95% CI: 28.82–32.84) and 11.1% percent of patients had at least 1 dose increase while 5.2% had a dose decrease (Table 2). The most common medication schedule dispensed was daily use of either patiromer 8.4 g (69.02%) or patiromer 16.8 g (12.58%) pouch (Table 3).

Patients had an average of 1.24 (95% CI: 1.20–1.29) patiromer treatment courses during the 180-day follow-up with the median course duration being 30 days (interquartile range: 30–31). The number of patients with only 1 treatment course was 356 (77.7%) with 102 (22.3%) patients having >1 treatment course. The average prescribed daily dose was 8.93 g (95% CI: 8.66–9.27) and the average observed daily dose was 8.42 g (95% CI: 8.05–8.79). Average course PDC was 0.96 (95% CI: 0.96–0.97) for all treatment courses (Table 2). Prescribed and observed daily dose in a sub analysis only
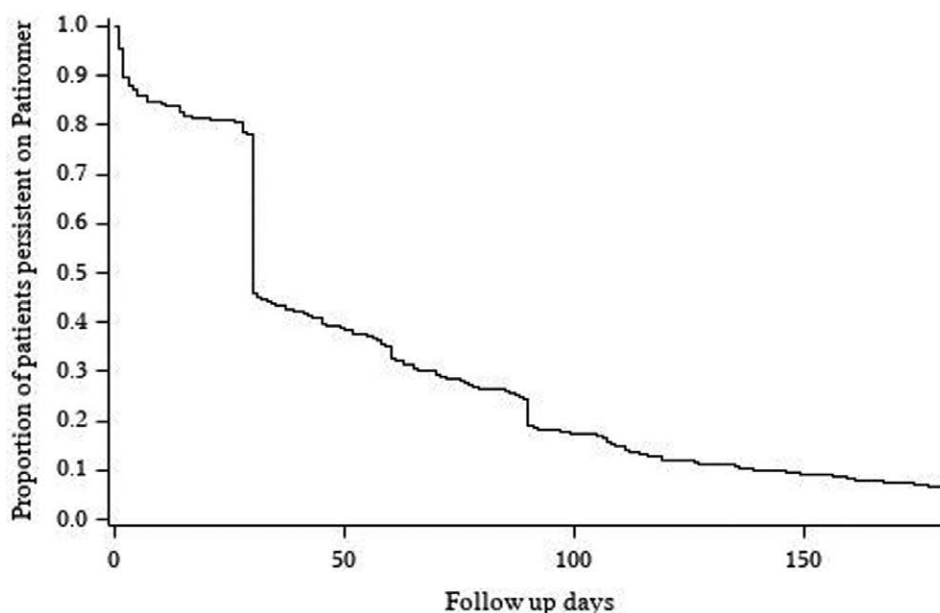

Figure 1. Persistence curve for patiromer: proportion of ESKD patients persistent on patiromer over time for the 180-day follow up after initial index on patiromer. ESKD = end stage kidney disease.

Table 1

Baseline demographics.

No. of patients	N = 458
Demographic date (as of index date)	Mean ± SD (95% CI)
Age	66.3 ± 9.6 (65.4–67.2)
Age categories	N (%)
<35 yr	3 (0.7)
35–50 yr	18 (3.9)
51–64 yr	170 (37.1)
65–74 yr	197 (43)
≥75 yr	70 (15.3)
Sex	
Male	446 (97.4)
Female	12 (2.6)
Race/ethnicity	
Hispanic	35 (7.6)
Caucasian non-Hispanic	176 (38.4)
African American non-Hispanic	205 (44.8)
Asian non-Hispanic	4 (0.9)
American Indian or Alaska native non-Hispanic	2 (0.4)
Unknown	42 (7.9)
Comorbidities (within 365 d prior to the index date)	
Cancer	174 (38.0)
Cardiac dysrhythmias	138 (30.1)
Cerebrovascular disease	87 (19.0)
Chronic pulmonary disease	116 (25.3)
Congestive heart failure	227 (49.6)
Coronary artery disease	205 (44.8)
Diabetes type II	331 (72.3)
Liver disease	74 (16.2)
Myocardial infarction	45 (9.8)
Peptic ulcer disease	14 (3.1)
Peripheral vascular disease	149 (32.5)
Medications (within 365 d prior to the index date)	
Amiodarone	18 (3.93)
Beta blocker	356 (77.73)
Cyclosporine/tacrolimus	66 (14.41)
Digoxin	5 (1.09)
Loop diuretic	222 (48.47)
Potassium sparring diuretic	1 (0.22)
Thiazide diuretic	47 (10.26)
Insulin	193 (42.14)
NSAID	22 (4.8)
ACE In/ARB	186 (40.61)
Direct renin inhibitor	1 (0.22)
Mineralocorticoid receptor antagonist	22 (4.8)
SPS	129 (28.17)
Healthcare resource utilization (within 365 d prior to the index date)	
Patients w ≥1 hospitalizations (n, %)	311 (67.9)
Patients w ≥1 ED visit (n, %)	367 (80.1)
Patients w ≥1 outpatient visit (n, %)	458 (100)
	Mean ± SD (95% CI)
Hospitalizations per patient	2.73 ± 2.17 (2.49–2.98)
Length of stay in d	5.89 ± 6.01 (5.22–6.56)
ED visits per patient	4.48 ± 3.99 (4.07–4.89)
Outpatient visits per patient	84.3 ± 61.41 (78.66–89.94)

ACE In = angiotensin-converting enzyme inhibitor, ARB = angiotensin II receptor blockers, CI = confidence interval, ED = emergency department, SD = standard deviation, SPS = sodium polystyrene sulfonate, NSAID = non-steroidal anti-inflammatory drugs.

looking at the 1st course were similar and there was no change in course PDC (Table S1, Supplemental Digital Content, http://links.lww.com/MD/I171). There were 87 (15.3%) courses that were censored either at the end of the 180-day follow-up period or when patient died during a treatment course, and the persistence probability curve show <10% remained persistent on their course at the end of the follow-up (Table 2) (Fig. 1).

4.3. Changes in serum K+

The average serum K+ concentration for the primary analysis during baseline and the 3 follow-up intervals (1–30, 31–91, and

Table 2

Course and dispensing level patiromer utilization during 6-month follow up period.

Patients, N	458
	N (%)
Patients with ≥1 dose increase	51 (11.1%)
Patients with ≥1 dose decrease	24 (5.2%)
Patients with 1 course	356 (77.7%)
Patients with >1 course	102 (22.3%)
	Mean (95% CI)
Count of patiromer dispensing events per patient	2.13 (1.99–2.27)
Cumulative grams dispensed per patient	593.92 (535.02–652.83)
Day supplied per dispensing	30.83 (28.82–32.84)
Number of treatment courses per patient	1.24 ± 0.48 (1.20–1.29)
Treatment course prescribed daily dose	8.93 (8.6–9.27)
Treatment course observed daily dose	8.42 (8.05–8.79)
Treatment course PDC	0.96 (0.95–0.97)
Median treatment course duration (d)	30 (IRQ: 30–31)
	Courses (c = 570), **c** (%)
*Censored courses at the end of follow up time	87 (15.3%)
Active courses at the end of follow up period	74 (13%)
Courses in which a patient died during course	14 (2.5%)

c is the total number of patiromer drug courses.

CI = confidence interval, IRQ = interquartile range, PDC = proportion of days covered.

*Courses were censored if patient died during a course; and if the course was active at the end of 180-day follow up the course was censored to the length of time it was active during the 180-day follow up period.

Table 3

Estimated medication schedule groups.

	n = (978)	Percentage
8.4 g less than every other d	67	6.85
8.4 g every other d	33	3.37
8.4 g less than daily	53	5.42
8.4 g daily	675	69.02
16.8 g less than daily	7	0.72
16.8 g daily	123	12.58
*16.8 g greater than daily	20	2.04

Medication schedule groups represents an estimation of how often the patient was instructed to take patiromer for an individual dispensing event. N is the total number of patiromer dispensing events.

*Patiromer is available as 8.4 g, 16.8 g, and 25.2 g packet strengths but we did not observe any dispensing events of the 25.2 g packet strengths in our pharmacy dispensing data.

92–182) were 5.91 mEq/L (95% CI: 5.85–5.97), 4.94 mEq/L (95% CI: 4.86–5.03), 4.89 mEq/L (95% CI: 4.8–4.98) and 4.88 mEq/L (95% CI: 4.8–4.96), respectively. For the secondary analysis, the average serum K+ concentration during baseline and the 3 follow-up intervals (1–30, 31–91, and 92–182) were 5.49 mEq/L (95% CI: 5.44–5.54), 4.98 mEq/L (4.9–5.06), 4.93 mEq/L (4.86–5.01), and 4.87 mEq/L (4.80–4.94), respectively (Fig. 2). The mean change in serum K+ was 1.02 mEq/L (95% CI: 0.92–1.11) from baseline to follow-up interval days 1 to 30, 1.04 (95% CI: 0.93–1.14) from baseline to follow-up interval days 31 to 91, and 1.05 (95% CI: 0.96–1.15) from baseline to follow-up interval days 92 to 183 (Table 4). The frequency of patients with specific categories of K+ values are reported in Table 4.

5. Discussion

This study described the use of patiromer among US veteran patients with ESKD. Our study found that most patients experienced only 1 patiromer treatment episode during the follow-up period and half of the population discontinued their course within 30 days of initiating patiromer. Moreover, nearly half of the population received only 1 dispensing
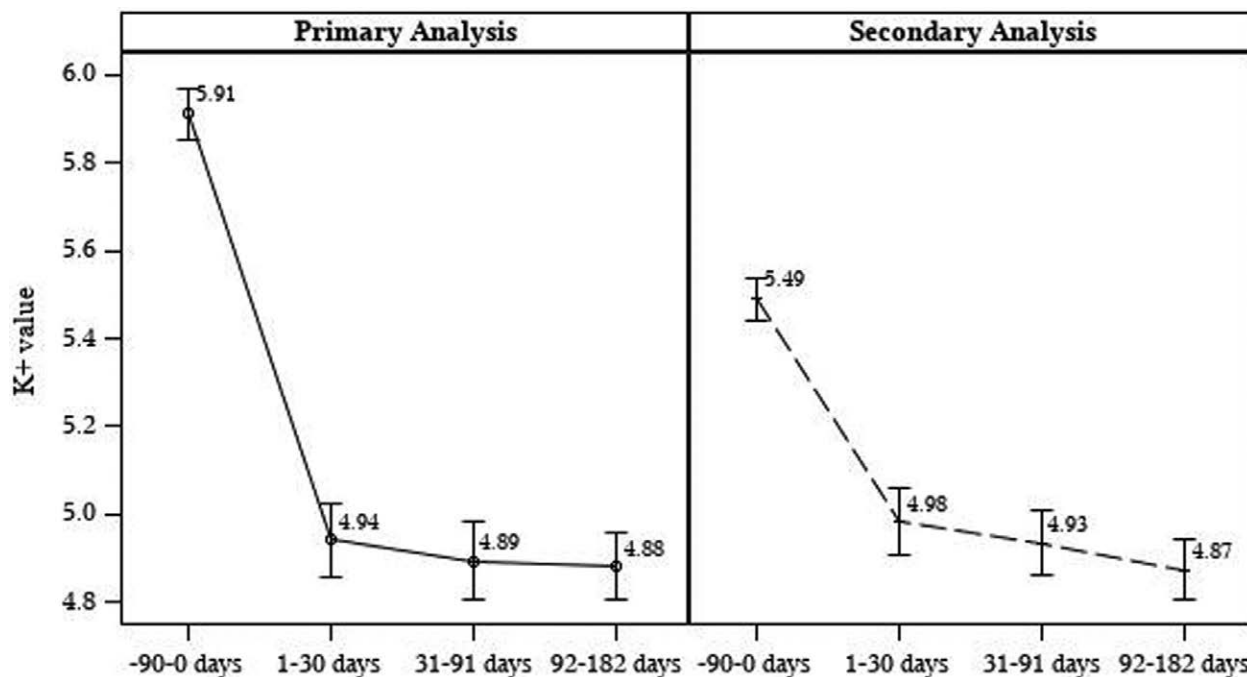
Figure 2. The primary analysis is change between mean K+ closest to patiromer index compared to mean K+ values closest the end of the follow up intervals. The secondary analysis is change between mean average K+ value during 90-day baseline period versus mean average K+ values of follow up intervals.

during their patiromer treatment course. Nonetheless, serum K+ levels were lower during follow up, and the decrease of approximately 1 mEq/L was maintained during each follow-up interval.

The primary utilization measure in this study was based on patiromer treatment courses that were intended to define episodes of patiromer treatment.[23] Defining treatment courses allowed us to examine duration of treatment, which is a measure of persistence. The dispensing event data revealed that most patients received daily dosing of either 1 or 2 of the 8.4 g packets; nevertheless, approximately 15% of patients appeared to have alternative dosing schedules. A manual review of medication instructions with alternative dosing schedules found these patients were instructed to use patiromer on non-dialysis days or use patiromer on days during the long interdialytic interval. Dose escalation during a patiromer treatment episode was not common. Only a small proportion of patients passed away during a patiromer treatment episode, which indicated that death did not have a significant impact on the observed treatment duration.

Changes in serum K+ were analyzed in 2 ways: serum K+ labs closest to the end of each follow-up interval and the average of all tests during each interval. We observed consistent results between these 2 approaches as they both showed significant decreases in serum K+ values when compared to baseline (Fig. 2). In addition to the observed decreases in serum K+, the proportion of patient with K+ levels considered normal or mild hyperkalemia increased during the follow-up intervals when compared to baseline. The proportion of patients who experienced hypokalemia (serum K+ <3.5 mEq/L) was minimal, as would be expected based on trial data. This study found that initiation of patiromer in ESKD patients was associated with improvements in obtaining K+ homeostasis. The observed changes in serum K+ support findings of a previous evaluation of hyperkalemia treatment with patiromer in ESKD patients that also demonstrated lowering effects of patiromer when comparing post patiromer K+ values to pre patiromer K+ values.[3,14]

Optimal utilization of patiromer in patients with ESKD is not well understood. We are unaware of previous studies that attempted to understand long term hyperkalemia treatment with patiromer in ESKD patients. Clinical trials demonstrated that daily patiromer effectively reduced and maintained serum K+ for up to 52 weeks in non-dialysis patients but only up to 7 days in HD patients, which fails to address questions surrounding longer treatment duration in ESKD patients.[2,15] We observed shorter durations that suggest patients are not using patiromer chronically or long-term but we do not know if that is driven by patient factors or providers not intending to use patiromer for longer periods, which may reflect the inherent complexity of managing serum K+ homeostasis in ESKD patients. Increased variability of serum K+ levels in ESKD patients resulting from factors like type of dialysis, dialysate concentrations, medications, and comorbid disease may require frequent treatment adjustments to reach and maintain serum K+ goals.[2,24] This study demonstrated that patiromer appeared to be a useful tool for lowering K+ levels in ESKD patients that suffered from hyperkalemia.

5.1. Limitations

This study was descriptive and not designed to isolate the impact of patiromer on average serum K+ during the follow-up intervals. It is possible that changes in serum K+ are a result of multiple influences to reduce K+ in veteran patients with hyperkalemia. Nevertheless, the immediate and sustained changes in average K+ indicate that patiromer is an important influence on K+.

The ICD codes used to define our population signify chronic dialysis treatment. They do not, however, differentiate HD and peritoneal dialysis (PD). Accurate identification of HD requires US Renal Data System data since HD is often outsourced to non-VA dialysis clinics. Unfortunately, access to US Renal Data System data for veterans is only updated periodically and would not be complete for our population. We believe the impact of grouping PD with HD in this study is minimal because previous studies done in the VA have reported only 7% of veterans diagnosed with ESKD are receiving PD while the rest are receiving HD treatment in dialysis centers or at home.[25]

Table 4

Changes in serum potassium values from baseline period in 3 follow up interval including days 1 to 30, 31 to 91, and 92 to 182.

No. of patients	n = 458		
Baseline	Mean (95% CI)	Med (IQR)	*P* value
K+ value	5.91(5.85–5.97)	5.8(5.5–6.3)	
K+ categories	n (%)		
K+ 5.1–5.4	106 (23.1)		
K+ 5.5–5.9	186 (40.6)		
K+ ≥6.0	166 (36.2)		
K+ missing	–		
Follow up 1–30 d	Mean (95% CI)		
K+ value	4.94 (4.86–5.03)	4.9(4.4–5.4)	
K+ change from baseline	−1.02 (0.92–1.11)		< .01
K+ categories	n (%)		
K+ <3.5	4 (0.87)		
K+ 3.5–5.1	171 (37.3)		
K+ 5.1–5.4	61 (13.3)		
K+ 5.5–5.9	51 (11.1)		
K+ ≥6.0	20 (4.4)		
K+ missing	151 (33)		
Follow up 31–91 d	Mean (95% CI)		
K+ value	4.89(4.8–4.98)	4.8(4.3–5.3)	
K+ change from baseline	−1.04 (0.93–1.14)		< .01
K+ categories	n (%)		
K+ <3.5	11 (2.4)		
K+ 3.5–5.1	208 (45.4)		
K+ 5.1–5.4	58 (12.7)		
K+ 5.5–5.9	40 (8.7)		
K+ ≥6.0	34 (7.4)		
K+ missing	107 (23.4)		
Follow up 92–182 d	Mean (95% CI)		
K+ value	4.88(4.8–4.96)	4.9(4.4–5.3)	
K+ change from baseline	−1.05 (0.96–1.14)		< .01
K+ categories	n (%)		
K+ <3.5	6 (1.3)		
K+ 3.5–5.1	201 (43.9)		
K+ 5.1–5.4	72 (15.7)		
K+ 5.5–5.9	51 (11.1)		
K+ ≥6.0	21 (4.6)		
K+ missing	107 (23.4)		

Serum K+ concentration values were those closest to the end of the baseline period and follow up intervals. Change of K+ values is the average difference in K+ concentration between the baseline value and each follow up intervals value.

CI = confidence interval, IRQ = interquartile range, K+ = potassium.

Another limitation is the lack of control between the timing of dialysis and K+ measurements. Routine or maintenance serum K+ levels are drawn on dialysis days prior to starting dialysis. Ascertaining maintenance K+ levels versus non-maintenance K+ levels requires careful consideration due to variability that can exist in serum K+ levels taken during maintenance pre-dialysis laboratories and non-maintenance levels that fall outside of a patient's normal cadence of care. Potential inclusion of non-maintenance K+ values, such as levels drawn during an inpatient stay, would make the change in K+ level findings hard to interpret due to the difficulty of knowing the relationship between K+ levels and HD events. We attempted to mitigate the impact of non-maintenance serum K+ levels on our results by developing a method to exclude levels where the timing and frequency were consistent with non-maintenance care such as acute inpatient stays. The similarity observed between our primary and secondary analysis of change in serum K+ provides confidence that the observed levels consist of maintenance K+ levels, as our assumption would be that a significant difference would be observed with the inclusion of all K+ levels during each interval if they reflected non-maintenance care.

Our analysis may be an underestimation of patiromer's effect on serum K+ due to our study design which evaluates the value closest to the end of each follow-up for every patient that initiated patiromer without regard to whether patients are currently on patiromer at the time the laboratory measure was performed. Even with this known limitation our study demonstrates a significant lowering and stabilizing of serum K+ levels in a population of lower-than-expected persistence and duration of treatment and it would be a reasonable assumption that we would observe an even more robust effect in those patients who continued patiromer.

6. Conclusion

Our study adds to the limited research surrounding the use of patiromer in patients diagnosed with ESKD, and we found when veteran patients diagnosed with ESKD are treated with patiromer for hyperkalemia there is a significant lowering effect of serum K+ values when compared to pre-patiromer values.[2,3,12,18] Most patients did receive daily dosing but did not remain on patiromer throughout the follow-up period. Observed patiromer treatment duration was shorter than anticipated, nevertheless, the robust reductions in serum K+ value observed demonstrates that patiromer is an efficient tool in the treatment of hyperkalemia in patients diagnosed with ESKD. Additional research with extended follow up time >6 months would be useful in determining longer term utilization patterns of patiromer in ESKD patients as well to understand provider decision-making and intention surrounding short treatment intervals when using patiromer in ESKD patients.

Author contributions

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