



ORIGINAL ARTICLE

Low dialysis potassium bath is associated with lower mortality in end-stage renal disease patients admitted to hospital with severe hyperkalemia

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ABSTRACT

Background. Hyperkalemia is a modifiable risk factor for sudden cardiac death, a leading cause of mortality in hemodialysis (HD) patients. The optimal treatment of hyperkalemia in hospitalized end-stage renal disease (ESRD) patients is nonexistent in literature, which has prompted studies from outpatient dialysis to be extrapolated to inpatient care. The goal of this study was to determine if low-potassium dialysate 1 mEq/L is associated with higher mortality in hospitalized ESRD patients with severe hyperkalemia (serum potassium >6.5 mmol/L).

Methods. We conducted a retrospective study of all adult ESRD patients admitted with severe hyperkalemia between January 2011 and August 2016.

Results. There were 209 ESRD patients on HD admitted with severe hyperkalemia during the study period. Mean serum potassium was 7.1 mmol/L. In-hospital mortality or cardiac arrest in ESRD patients with severe hyperkalemia was 12.4%. Median time to dialysis after serum potassium result was 2.0 h (25, 75 interquartile range 0.9, 4.2 h). Totally, 47.4% of patients received dialysis with 1 mEq/L concentration potassium bath. The use of 1 mEq/L potassium bath was associated with significantly lower mortality or cardiac arrest in ESRD patients admitted with severe hyperkalemia (odds ratio 0.27, 95% confidence interval 0.09–0.80, $P = 0.01$).

Conclusion. We conclude that use of 1 mEq/L potassium bath for treatment of severe hyperkalemia (>6.5 mmol/L) in hospitalized ESRD patients is associated with decreased in-hospital mortality or cardiac arrest.

Keywords: dialysis potassium bath, ESRD, in-hospital mortality, severe hyperkalemia

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INTRODUCTION

Hyperkalemia is a common cause for admission in end-stage renal disease (ESRD) patients [1]. Hyperkalemia is associated with higher mortality in all hospitalized patients as well as ESRD patients [2–4]. However, there is a lack of data in literature to guide treatment in ESRD patients admitted with hyperkalemia.

Predialysis hyperkalemia is associated with higher mortality in ESRD patients on maintenance hemodialysis (HD) in the

outpatient setting [5]. A low-potassium dialysate bath, defined as concentration of 1 mEq/L of potassium (1K), for maintenance HD in ESRD patients, is associated with higher mortality compared with 2 mEq/L or 3 mEq/L potassium (2K or 3K) dialysis bath in the outpatient setting [5–8]. Since these data were published, the use of 1K bath has decreased significantly for outpatient maintenance dialysis. Due to extrapolation of these studies from the outpatient setting to the inpatient setting, the use of 1K bath has decreased in the inpatient setting as well.

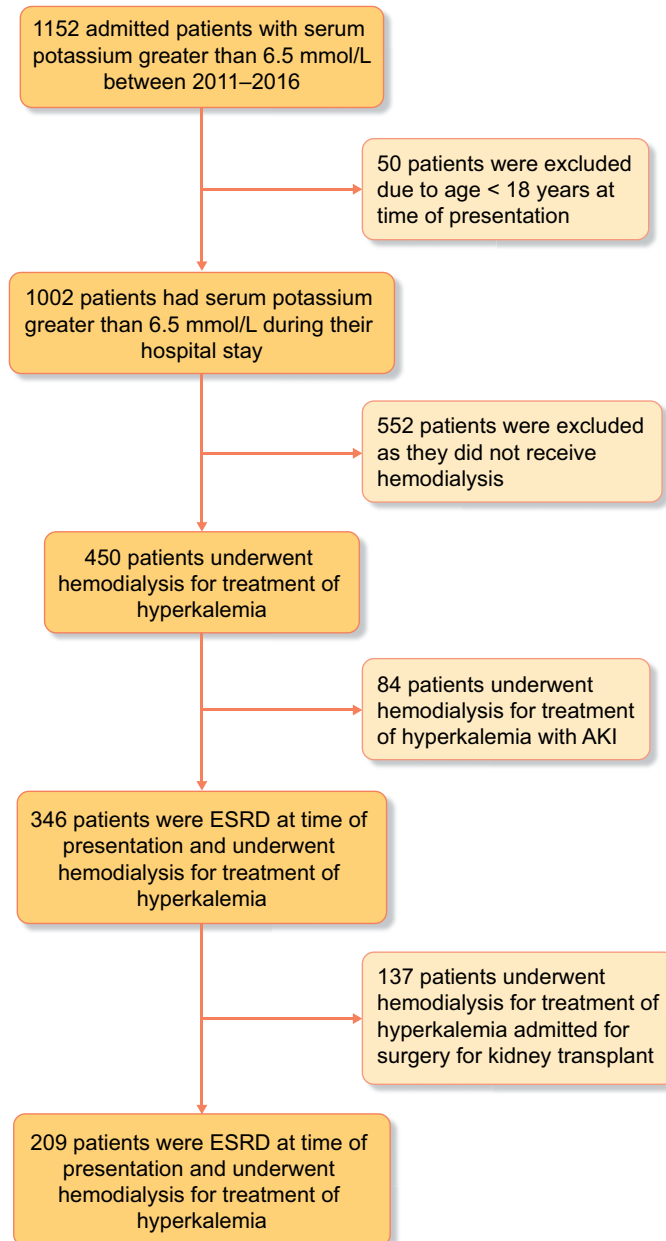


FIGURE 1: Patients included in the study.

However, a 1K bath is more efficient for removal of potassium from serum because of a high gradient between serum and dialysate potassium [9]. There are no data comparing the dialysis potassium bath concentration in the inpatient setting. ESRD patients admitted to the hospital with hyperkalemia have laboratory testing more often, and therefore are monitored more closely as compared with patients in an outpatient dialysis unit. In addition, the majority of hospitalized patients have cardiac monitoring and get a repeat potassium assessed in 12–24 h after the dialysis session for hyperkalemia. The primary aim of this study was to determine whether the use of 1K dialysis bath for treatment of severe hyperkalemia in hospitalized ESRD patients was associated with more in-hospital death or cardiac arrest as compared with higher potassium dialysis bath.

MATERIALS AND METHODS

Study population and data collection

The study population included adult patients (>18 years of age) with ESRD admitted to a single tertiary care hospital between 1 January 2010 and 31 December 2016 (Figure 1) and who had a serum potassium levels >6.5 mmol/L. The demographics, comorbidities and laboratory values including serum potassium levels were obtained from the electronic health record of our hospital. The 1K bath cohort in the study was defined as if the patient received dialysis with 1 mEq/L bath at anytime during their dialysis time. The primary outcome was in-hospital death or cardiac arrest. The patients were followed through the hospital stay.

Statistical analysis

Continuous variables were compared between groups with Student’s t-test and Kruskal–Wallis test. Categorical variables were compared between groups with chi-square tests. Univariable and multivariable Cox proportional hazards models were used to assess independent associations between baseline characteristics and mortality. Multivariable hazard ratios (HRs) were calculated after adjusting for age, sex, race, time to dialysis, history of diabetes mellitus, history of hypertension and serum potassium. All analyses were performed using Stata (StataCorp LP, College Station, TX, USA).

Table 1. Baseline characteristics for hospitalized ESRD patients with severe hyperkalemia

Patient population	n = 209
Age (years), mean ± SD	53.5 ± 14.8
Ethnicity (Caucasian), % (n)	74.6 (156)
Men, % (n)	60.3 (125)
Body mass index (kg/m ²), mean ± SD	29.7 ± 0.5
Diabetes mellitus, % (n)	76.5 (247)
Hypertension, % (n)	96.7 (335)
Length of stay (days), mean ± SD	8.3 ± 18.0
Albumin (g/dL), mean ± SD	3.2 ± 0.69
Serum creatinine (mg/dL), mean ± SD	9.0 ± 3.9
Serum potassium (mmol/L), mean ± SD	7.1 ± 0.04
Serum CO ₂ levels (mmol/L), mean ± SD	22.2 ± 5.4
Serum hemoglobin (mg/dL), mean ± SD	10.2 ± 0.1

RESULTS

Baseline patient characteristics

A total of 1002 patients were admitted to the hospital between January 2011 and December 2016 with a serum potassium >6.5 mmol/L. Of these, 209 (20.9%) patients had ESRD and were included in the study (Figure 1). The mean (±SD) age was 53.5 (±14.8) years (Table 1), with 74.6% identifying as Caucasians and 60% being men. Comorbidities included 76.5% with diabetes mellitus and 96.7% had history of hypertension. The mean serum potassium was 7.1 mmol/L.

Dialysis treatment for hyperkalemia

The median time to dialysis after the serum potassium resulted was 2 h (25–75 p, 0.9–4.2) (Table 2). The mean dialysis duration was 3.1 h. The median ultrafiltration during dialysis was 2 L (25–75 p, 0.0–3.0). Only 11 (5.3%) patients were on continuous renal replacement therapy. Forty-seven percent of patients were on 1K bath for some portion of the dialysis session. Of these patients, 90% (89 of 99 patients) were on 1K bath during the first hour of dialysis (Table 3). As the dialysis session progressed, fewer patients were on 1K bath and were changed to higher K bath. In total, 32, 25 and 22% were on 1K bath during the second, third and fourth hour of dialysis, respectively.

Primary outcome

Among the 209 patients included in the study, 26 (12.4%) met the criterion for primary outcome: 13 (6%) died and 15 (7.5%) had cardiac arrest during the hospitalization. When assessing the dialysis prescription, 8 (8%) patients died or had cardiac arrest if they were ever on 1K bath, whereas 18 (16%) patients died or had cardiac arrest among those who were never on 1K bath during the dialysis session after the hyperkalemia result. The use of a 1K bath was associated with decreased the risk of death or cardiac arrest, which remained statistically significant even after adjusting for age, sex, race, history of diabetes mellitus, hypertension, serum potassium level and time to dialysis (HR 0.27, 95% confidence interval 0.09–0.80, P = 0.01; Table 4).

DISCUSSION

In this study, we found that 47% of ESRD patients admitted to hospital with severe hyperkalemia defined as serum potassium level >6.5 mmol/dL were treated with a 1K dialysis bath. The use of the 1K bath in this population was associated with 77% lower risk for mortality or cardiac arrest compared with higher potassium concentration dialysis bath, even after adjusting for

Table 2. Variables for dialysis treatment for ESRD patients admitted to hospital with hyperkalemia

Dialysis prescription factors	n = 209
Time from K results to dialysis (h), median (25–75 p)	2.0 (0.9–4.2)
Dialysis duration (h), mean ± SD	3.1 ± 0.1
Qb (mL/min), median (25–75 p)	400 (350–400)
Qd (mL/min), median (25–75 p)	600 (600–800)
UF (L/session), median (25–75 p)	2.0 (0.0–3.0)
CRRT use, % (n)	5.3 (11)
1K bath used, % (n)	47.4 (99)

K, potassium; Qb, blood flow rate; Qd, dialysate flow rate; UF, ultrafiltration; CRRT, continuous renal replacement therapy.

Table 3. Potassium bath used for dialysis treatment for ESRD patients admitted to hospital with hyperkalemia

K bath	First dialysis hour (n = 199), % (n)	Second dialysis hour (n = 195), % (n)	Third dialysis hour (n = 170), % (n)	Fourth dialysis hour (n = 79), % (n)
1	44.7 (89)	32.3 (63)	25.3 (43)	22.8 (18)
2	48.7 (97)	61 (119)	62.4 (106)	60.8 (48)
3	6.0 (12)	6.2 (12)	10.6 (18)	10.1 (8)
4	0.5 (1)	0.5 (1)	1.8 (3)	6.3 (5)

Table 4. Hazard ratio for mortality in hospitalized ESRD patients with severe hyperkalemia

	HR (unadjusted) (95% CI)	Adjusted HR (95% CI)	P-interaction
1 K bath versus other	0.45 (0.18–1.09)	0.27 (0.09–0.80)	0.01

Adjusted for age, sex, race, history of diabetes mellitus, history of hypertension, serum potassium, time to dialysis. CI, confidence interval.

age, sex, race, history of diabetes mellitus, hypertension, serum potassium levels and time to dialysis.

Hyperkalemia is among the top five causes for admission to hospital for ESRD patients [1]. High serum potassium in any hospitalized patients is an independent risk factor for increased mortality [4, 10]. Despite being a common occurrence in ESRD patients and associated with poor outcomes, there is no treatment guiding literature. To our knowledge, this is first study to assess the effects of different potassium concentration dialysis baths on patient outcomes used for the treatment of hyperkalemia in hospitalized ESRD patients. The use of 1 mEq/L potassium bath compared with higher potassium bath concentrations has been associated with higher mortality in outpatient maintenance dialysis [5–8]. The results from these studies have been extrapolated to the inpatient setting, making many clinicians reluctant to use 1K bath in the inpatient setting [11]. The use of 1K bath is associated with increased removal of total potassium during the dialysis session, and thus is much more likely to achieve a lower post-treatment serum potassium [9, 12]. There are significant differences in outpatient maintenance dialysis versus dialysis in inpatient setting. First, patients are monitored more closely for their cardiac rhythm and hemodynamics in inpatient settings compared with outpatient dialysis units. Second, repeat potassium levels are checked frequently in the inpatient setting, making replacement of over-corrected potassium seamless. Third, the use of a 1K bath in the hospital is used for only one to two dialysis sessions, as compared with every outpatient dialysis session for a prolonged time. A longer duration of 1K bath as used in the outpatient maintenance dialysis setting, three times per week over a period of time, could lead to sustained depletion of potassium from the intracellular compartment. This could limit the capacity of the patient to correct serum the potassium due to rebound, i.e. movement of potassium from the cells into the serum after the dialysis session with low-potassium bath [13]. Therefore, extrapolating these studies from the outpatient practice should not guide inpatient treatment practices.

We find that use of 1K bath is associated with lower in-hospital mortality and cardiac arrest. While this study shows associations and cannot predict that the hyperkalemia is causal, more potassium can be removed with a single dialysis session and more rapid normalization of serum potassium with

dialysis with 1K bath as compared with dialysis with higher potassium bath. There are data in nondialysis-dependent patients indicating that faster correction of hyperkalemia was associated with lower in hospital mortality [4].

There are significant limitations to this study. It is a single-center study and hence influenced by the clinical practice trends and patient demographics at our center. Another limitation is that is a retrospective observational study. Despite these limitations, we find a modifiable factor that can decrease the mortality in hospitalized ESRD patient.

In conclusion, this study identified that the use of 1K dialysis bath in hospitalized ESRD patients with severe hyperkalemia was associated with significantly lower risk of death or cardiac arrest compared with higher potassium dialysis bath. This modifiable treatment factor remained significant when correcting for other prescription, demographic and comorbidity factors. Larger randomized clinical trials are needed to test this association, to try to improve the outcomes of hospitalized ESRD patients.

AUTHORS' CONTRIBUTIONS

T.S. contributed to the concept, data compilation, performing statistics, preparation and writing of the manuscript; S.A. and A.G. contributed to the data compilation, review and proofreading of the manuscript; B.C.A. contributed to performing statistics, review and proofreading of the manuscript; L.M. contributed to the concept, mentoring, review and proofreading of the manuscript.

CONFLICT OF INTEREST STATEMENT

None declared.

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