Hyperkalemia and Sodium Polystyrene Sulfate Use in a Regional Training Hospital

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Background

Potassium is an essential electrolyte for the proper functioning of the nerves and muscles, including the heart and its conduction system. Although there is no internationally accepted definition for hyperkalemia, this condition is generally considered to be a serum potassium ion (K+) concentration above 5.0 mEq/L. Hyperkalemia is a frequent cause of patient morbidity during hospitalization. The guidelines of the National Kidney Foundation, KDIGO (Kidney Disease Improving Global Outcomes), and the UK Renal Association for the treatment of acute hyperkalemia recommend starting with intravenous calcium salts (gluconate or chloride) to stabilize cardiac membrane excitability and then administering intravenous short-acting insulin with intravenous glucose and/or a beta-2 agonist, such as albuterol nebulizer. Sodium bicarbonate is used to counteract acidosis and to shift K+ into cells. However, these are all temporizing measures. There are two primary methods for permanently removing K+ from the patient's body: diuretics via kidney excretion and K+-binding resins via gastrointestinal excretion. Renal elimination is typically selected at first; if this is insufficient, then administration of sodium polystyrene sulfate (SPS) resin to the gastrointestinal tract can be considered. Given the risk of colon ischemia and perforation, however, the US Food and Drug Administration (FDA) has suggested cautious SPS use, particularly for patients with pre-existing gastrointestinal concerns.

Methods

We evaluated the use of SPS to treat hyperkalemia in a 222-bed regional training hospital. We retrospectively evaluated hyperkalemia cases over 6 months (July–December 2019) and classified it into four categories by K+ concentration: mild (5.1–5.4 mg/dL), moderate (5.5–6.0 mg/dL), severe (6.1–7.0 mg/dL), and emergency (≥7.1 mg/dL). Certain patients were found to have multiple episodes of hyperkalemia and/or multiple doses of SPS during the same hospitalization. Each hyperkalemic event was taken as a data point and used in the analysis (Tables 1). To study the correlation between doses and SPS frequency on the one hand and gastrointestinal complications on the other, we had to use a different population number (N = 110) (Tables 3–5). If a patient was administered multiple doses of SPS, each hospitalization was considered to be a data point instead of each hyperkalemic event. We conducted chi-squared analyses.

Results

Total 701 hyperkalemic events were identified and reviewed (Table 1). The majority of patients were white (100%), male (53%), and 65 years old or above (65%). Of the 701 episodes of hyperkalemia, 65% were mild, 27.4% were moderate, 5.8% were severe, and 1.7% were emergency level. SPS was administered in 126 episodes in 701 hyperkalemic events where 9% of the mild, 31.2% of the moderate, 41.4% of the severe, and 50% of the emergency level. Given that K+ elimination through the kidneys should occur with a preserved glomerular filtration rate (GFR), we evaluated chronic kidney disease (CKD) and SPS administration. Of the patients with hyperkalemia administered SPS, 40.5% were CKD stage I-III and 59.5% were stage IV-V. The actual number of patients who received single or multiple doses of SPS was 110 patients. Among 110 patients, 25 patients received multiple doses of SPS during the same hospitalization and 5 were in mild level, 11 were in moderate, 6 were in severe and 3 were in emergency level (Table 2). 15 g of SPS was administered as initial dose in 50 patients but higher doses were prescribed in other 60 patients. Among the 60 patients, 16 patients were in mild. 43 patients received other hyperkalemia therapy such as insulin, sodium bicarbonate, beta-agonist, or diuretics prior to SPS. 67 patients did not receive other hyperkalemia therapy and 5 patients who did not receive the other therapy were at the emergency level. We also reviewed the electrocardiograms of the patients who were administered SPS and found evidence that hyperkalemic changes were present in 6% of the mild, 12% of the moderate, 15% of the severe, and 33% of the emergency cases. 47 patients did not have ECG 24 prior to SPS administration and 28 patients were in moderate to severe level. A total of 12 patients who had known gastrointestinal issues including colitis, gastric ulcer, ileus, small bowel obstruction, or diverticulitis prior, still received SPS.

Table 1. Characteristics of the Patients

Characteristic	Total (N=701)	SPS given (N=126)
Sex		
Male	373 (53%)	73 (57.9%)
Female	328 (47%)	53 (42.1%)
Median Age, Years	69 (19-98)	69 (26-91)
Distribution, n (%)		
≥65 years	455 (65%)	90 (71.4%)
<65 years	246 (35%)	36 (28.6%)
Hyperkalemic Range (mg/dL)		
Median Potassium Ion Level	5.3 (5.1-9.1)	5.6 (5.2-8.6)
5.1-5.4	456 (65.0%)	43 (9.4%)
5.5-6.0	192 (27.4%)	60 (31.2%)
6.1-7.0	41 (5.8%)	17 (41.4%)
≥7.1	12 (1.7%)	6 (50%)
Estimated Glomerular Filtration Rate		
Median eGFR (mL/min)		24 (3-≥60)
eGFR Distribution (mL/min)		
<15		34 (27.0%)
15-29		41 (32.5%)
30-59		39 (31.0%)
≥60		12 (9.5%)

The trend of SPS administration was also reviewed based on the eGFR range (Table 3). Alternate hyperkalemia therapy such as insulin, sodium bicarbonate, or diuretic was not considered in 31 patients with mild CKD and 27 patients with mild CKD received high doses of SPS.

Table 2. Trend of SPS Administration at Various K⁺ Levels

	K+ Range (mg/dL)				
	5.1-5.4	5.5-6.0	6.1-7.0	≥7.1	P
SPS					
Yes	37	52	15	6	0.000
No	413	132	25	6	
Frequency of SPS					
Once	32	41	9	3	0.073
Multiple	5	11	6	3	
Initial Dose of SPS					
15 g	22	23	4	1	0.069
Higher	15	29	11	5	
Total Dose of SPS					
15 g	21	18	2	1	0.013
Higher	16	34	13	5	
Other Therapy Prior to SPS					
Yes	15	19	8	1	0.437
No	22	33	7	5	
ECG 24 Hr. Prior to SPS					
Yes	18	26	13	6	0.007
No	19	26	2	0	
Peaked T-waves Observed Prior to SPS	1 (6%)	3 (12%)	2 (15%)	2 (33%)	
GI Issue Prior to SPS	3	4	4	1	

Table 3. Trend of SPS Administration Based on eGFR Range

	eGFR Range (mL/min)				P
	<15	15-29	30-59	≥ 60	
Initial Dose of SPS					
15 g	12	16	15	7	0.624
Higher	17	19	20	4	
Total Dose of SPS					
15 g	11	12	12	7	0.325
HIgher	18	23	23	4	
Other Therapy Prior to SPS					
Yes	10	18	10	5	0.230
No	19	17	25	6	
ECG 24 Hrs. Prior to SPS					
Yes	16	24	17	6	0.392
No	13	11	18	5	

The relationship between GI complications including upper gastrointestinal and/or duodenal ulcers, ischemic colitis, acute diverticulitis, and rectal ulcers, and SPS doses were reviewed (Table 4). The patient who received higher doses of SPS had a higher incidence of possible GI complications but the majority of patients who received SPS either single or multiple SPS doses did not have possible GI complications.

Table 4. GI Complication Within 30 Days After SPS Administration

	Yes	No	P
Frequency			
Once	3	82	0.346
Multiple	2	23	
Total Dose			
15 g	2	40	0.932
Higher	3	65	

Table 5. Hyperkalemia Cases Based on eGFR

	K⁺ Range (mg/dL)			
eGFR	5.1-5.4	5.5-6.0	6.1-7.0	≥ 7.1
≥ 60	6	4	1	0
30-59	11	20	3	1
15-29	11	16	7	1
<15	9	12	4	4

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Discussion

Our study demonstrated SPS is often used in mild stages of hyperkalemia in patients with preserved eGFR. As shown in Table 5, 17 patients with mild hyperkalemia had mild CKD who should be able to renally eliminate K+. For such a group, other therapy should therefore be considered. The onset of action and duration of SPS is slow and varied. Patients with moderate to higher levels of hyperkalemia have a higher chance of developing cardiac arrhythmia. The administration of SPS alone without other temporizing treatments should be avoided. When we examined the patients' estimated GFR (eGFR) at the time of their hyperkalemia to determine whether the patients received higher initial and/or total SPS doses with a lower eGFR, no correlation was found between the initial (P = 0.624) or total doses (P = 0.325) and eGFR. As we expected, the patients with higher K+ levels had a greater likelihood of receiving SPS and higher total doses (P = 0.013); however, the patients' initial SPS dose (P = 0.069) and frequency (P = 0.073) did not depend on their K+ levels. Although the typical SPS dose frequency was "once," 25 of the 110 patients with hyperkalemia received multiple doses within 24 to 48 h and two cases in which SPS was continued to be administered even though the patient's potassium was in the normal level the following morning. This practice could increase the risk of hypokalemia, prolonged hospitalization, and increased costs. Not all the patients with hyperkalemia who received SPS underwent an electrocardiogram 24 h prior to their treatment; however, the patients with higher K+ levels had a greater likelihood of undergoing an ECG 24 h prior to SPS administration (P = 0.007). There were five cases of possible gastrointestinal complications with SPS within our study's time frame. These complications included upper gastrointestinal and/or duodenal ulcers, ischemic colitis, acute diverticulitis, and rectal ulcers. Our study did not show a correlation between GI complications and higher doses (P = 0.932) or SPS frequency (P = 0.346). However, a larger study is needed. Regardless, for patients with known gastrointestinal issues prior to SPS administration, we strongly advise against the use of SPS in these patients, given that it can increase the risk of gastrointestinal complications. We found one case of SPS administered to a patient with a normal K+ level. Based on our investigation, a provider was using SPS to treat constipation, which is one of the contraindications for using SPS. There was a study to attempt to warn providers of the safety concerns of SPS. A prospective study by Leaf et al. demonstrated that implementing an electronic alert in EMR, indeed, reduced SPS usage in an inpatient setting; however, the method still failed to prevent the use of SPS.

Conclusions

This retrospective review suggested that SPS is used often with mild stages of hyperkalemia without EKG evaluation or without hyperkalemic EKG changes prior to SPS administration. SPS is also often prescribed in patients with mild CKD who should be able to renally eliminate K+. SPS was administered in some patients with pre-existing GI concerns despite FDA warnings. We determined that SPS is being used quite aggressively in the community hospital. Clinicians should re-familiarize themselves with the practice guidelines regarding SPS use.

Sodium and Potassium Poly(styrene sulfonates):