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Acute Physical and Occupational Therapy and Serum Potassium: When Is It Safe?

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ABSTRACT

Purpose: High or low serum potassium (K^+) levels are associated with increased risk of cardiac arrhythmias. No research-based guidelines or suggested values for K^+ in regard to safe provision of physical therapist (PT) and occupational therapist (OT) services for patients in an acute care setting are currently available. This study was designed to determine whether patients with serum K^+ levels of 3.1 to 5.9 mmol/L can participate safely in acute PT and OT interventions without serious adverse events.

Methods: A total of 380 subjects admitted to an acute care hospital were stratified into groups with hypokalemia (K^+ levels of 3.1-3.4 mmol/L), hyperkalemia (K^+ levels of 5.1-5.9 mmol/L), or normal K^+ levels (K^+ levels of 3.5-5.0 mmol/L) and provided with standard PT or OT intervention. Baseline clinical characteristics and adverse outcomes were compared between groups.

Results: No serious adverse events occurred. Termination of treatment due to minor adverse events occurred in 8 (2%) subject cases and all occurred in the normal K^+ group (n = 8, 3%) ($P = .029$). Rates of adverse outcomes did not differ significantly between normal (n = 37, 15.5%) and abnormal K^+ (n = 26, 16.4%) groups.

Conclusions: Results of this study suggest that provision of PT and OT interventions for patients with serum K^+ levels of 3.1 to 5.9 mmol/L is safe.

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Serum potassium (K^+) levels outside the standard range of 3.5 to 5.0 mmol/L are associated with increased risk of cardiac arrhythmias.[1-6] Significant hypokalemia is associated with Q-T interval prolongation and subsequent risk of ventricular fibrillation,[7,8] while significant hyperkalemia is associated with peaked T waves and widened QRS complexes with subsequent risk for bradycardia and asystole.[9,10] As such, both hypo- and hyperkalemic states can put patients at risk for sudden cardiac death.[11,12] Patients with acute illness are at risk for K^+ imbalance and cardiac arrhythmias.[13-17] Mobility, activities of daily living, and exercise are frequently initiated by physical therapists (PTs) and occupational therapists (OTs) during hospitalization.[18,19] An exhaustive search of recent literature via PubMed did not provide clear guidelines or identify specific suggested values for K^+ in regard to safe provision of PT and OT service and/or mobilization of patients in an acute care setting; however, the American Physical Therapy Association's Academy of Acute Care provided a resource suggesting a symptom-based approach for treating patients with variable serum K^+ levels.[20,21] The current standard of practice at Henry Ford Hospital allows for provision of PT and OT interventions for patients with K^+ levels of 3.1 to 5.9 mmol/L and is based on expert recommendations from the cardiology and nephrology departments within the institution and is included in the rehabilitation department's laboratory values competency manual.[22] No serious adverse events in the treatment of these patients have been reported in greater than 10 years. However, there is a lack of compelling literature to demonstrate that PT and OT interventions pose no significant threat to this patient population. This study was designed to verify and validate our facility's guidelines that patients with serum K^+ concentrations of 3.1 to 5.9 mmol/L can participate safely in acute PT and OT interventions without serious adverse events to ensure that all eligible patients receive rehabilitation (rehab) services when necessary and appropriate and to provide evidence that is critically lacking in the literature.

METHODS

Data Collection

All patients admitted to Henry Ford Hospital with serum K^+ levels of 3.1 to 5.9 mmol/L were eligible for inclusion in this study. Exclusion criteria omitted individuals with potassium levels of 3.0 mmol/L or less and 6.0 mmol/L or greater, as well as individuals who did not meet the specified guidelines for vital signs, hemoglobin, platelets, blood glucose, and troponin values outlined by the Henry Ford Hospital Rehab Services Lab Values Competency and Reference Manual as listed in Table 1.[21,22] Those eligible to participate in the study were required to have heart rate and blood pressure monitored pre-, mid-, and post-treatment and documented in the daily therapy note.[20-23] For the purposes of this project, abnormal K^+ was subdivided into 2 groups: hypokalemia defined as K^+ levels of 3.1 to 3.4 mmol/L, and hyperkalemia defined as K^+ levels of 5.1 to 5.9 mmol/L. Normal K^+ levels were defined as 3.5 to 5.0 mmol/L. Standard PT and OT services were defined as "interventions designed to address patient-specific impairments in musculoskeletal, neuromuscular, integumentary, cardiovascular, pulmonary, and/or cognitive systems causing limitations in mobility or restrictions in activities of daily living." Treatment was terminated with onset or increase in any symptoms outlined in Table 1. Demographics collected included the following comorbidities: coronary artery disease, end-stage renal

TABLE 1. Exclusion Criteria and Criteria for Termination of Treatment

Exclusion Criteria	Criteria for Termination of Treatment
Resting heart rate <50 or >120 beats per minute prior to treatment	Numbness or tingling in any body part
Systolic blood pressure <80 or >180 mm Hg prior to treatment	Dizziness not resolved/improved (as defined by the patient) within 60 s of upright positioning
Diastolic blood pressure <40 or >110 mm Hg prior to treatment	Nausea/vomiting
Oxygen saturation levels ≤90% prior to treatment	Blurred vision
Hemoglobin: ≤7.0 g/dL	Heart rate increase >30 beats per minute above resting heart rate
Blood glucose <70 or >300 mg/dL	Change in systolic blood pressure of ≥30 mm Hg or change in diastolic blood pressure of ≤10 mm Hg
Troponin I: New-onset increase >0.2 ng/mL within 24 h prior to treatment, or elevation between 0.05 and 0.2 within 24 h prior to treatment	Anginal pain
	Shortness of breath

disease, chronic kidney disease, acute kidney injury, atrial fibrillation, hypertension, congestive heart failure, and chronic obstructive pulmonary disease. These were chosen to reflect the comorbidities most commonly associated with altered potassium levels and/or those frequently associated with electrolyte imbalance. The therapist also recorded the subject's hospital unit (differentiated by patient population, intensive care unit, general practice unit, and telemetry). These demographics and adverse outcomes were compared between subjects with normal K^+ levels and those with hypo- or hyperkalemia. This study was approved by the Henry Ford Health System Institutional Review Board.

Data Analysis

All data were categorical and presented as count and column percentages. Bivariate analyses were carried out using a 2×2 χ^2 or Fisher exact test if an expected cell count was less than 5 and included K^+ (normal/abnormal) versus the presence of each comorbidity, K^+ (normal/abnormal) versus occurrence of each adverse event, and K^+ (normal/abnormal) versus need for termination of treatment. Statistical significance was set at $P < .05$. All analyses were performed using SAS 9.4 (SAS Institute Inc, Cary, North Carolina).

RESULTS

A total of 380 subjects were enrolled in this study, including 68 subjects in intensive care units, 254 subjects in general practice units, and 58 subjects in a cardiology telemetry unit. The association between comorbidities and K^+ is provided in Table 2. Thirty-seven percent of participants (n = 140) had abnormal K^+ levels at the time of PT or OT intervention. Sixty-three percent of participants (n = 240) had normal K^+ levels at the time of PT or OT intervention. Hypokalemia was present in 97 (26%) patient cases and hyperkalemia was present

TABLE 2. Demographics

Demographics (Count)	Normal K^+ (n = 240)	Abnormal K^+ (n = 140)	*P*[a]
Coronary artery disease[b]	30 (13%)	20 (14%)	.619
End-stage renal disease[b]	0	8 (6%)	**<.001**
Chronic kidney disease[b]	32 (13%)	27 (19%)	.122
Acute kidney injury[b]	21 (9%)	20 (14%)	.093
Atrial fibrillation[b]	33 (14%)	21 (15%)	.736
Hypertension[b]	117 (49%)	85 (61%)	**.024**
Congestive heart failure[b]	28 (12%)	22 (16%)	.260
Chronic obstructive pulmonary disease[b]	23 (10%)	15 (11%)	.723
Medical GPU[c]	44 (18%)	24 (17%)	N/A
Medical ICU[c,d]	9 (4%)	5 (4%)	N/A
Surgical GPU[c]	29 (12%)	15 (11%)	N/A
Surgical ICU[c,d]	39 (16%)	12 (9%)	N/A
Ortho GPU[c]	13 (5%)	11 (8%)	N/A
Neuro GPU[c]	48 (20%)	22 (16%)	N/A
Oncology GPU[c]	23 (10%)	13 (9%)	N/A
Cardiopulmonary GPU[c,d]	29 (12%)	29 (21%)	N/A
Cardiopulmonary ICU[c,d]	3 (1%)	0	N/A

Abbreviations: GPU, general practice unit; ICU, intensive care unit; N/A, not applicable.
[a]Values in boldface are statistically significant.
[b]Comorbidity.
[c]Hospital unit.
[d]Telemetry monitoring available.

in 43 (11%) patient cases. No serious adverse events occurred in any study participant with normal or abnormal K^+ levels. Minor adverse events occurred in 48 subjects. As expected, no adverse events occurred when highest level of mobility achieved was "nothing," "sitting edge of bed," or "marching in place." During interventions that included "transfer from bed to chair," 7 subjects experienced dyspnea and 1 subject experienced tachycardia. Two episodes of dyspnea were reported in subjects who achieved "standing" but not "marching in place." Termination of intervention due to minor adverse events occurred in 8 (2%) subject cases. Significantly, all treatment sessions requiring termination were in the normal K^+ group (n = 8, 3%) as compared with subjects with abnormal K^+ (n = 0, 0%) ($P = .029$). Dyspnea was the only minor adverse event significantly higher in the group with abnormal K^+ levels (n = 19, 14%) than in the group with normal K^+ levels (n = 16, 7%) ($P = .028$). End-stage renal disease ($P = .001$) and hypertension ($P = .024$) were comorbidities found significantly higher in the abnormal K^+ group. An analysis of the differences in K^+ levels between units was completed and reported in Table 2; however, P values could not be determined because the number of categories exceeded the limits of the statistical analysis. Serious adverse events were defined as "deaths or cardiopulmonary arrests requiring resuscitation during a PT or OT session." Minor

TABLE 3. Adverse Events

Adverse Event (Count)	Normal K^+ (n = 240)	Abnormal K^+ (n = 140)	P[a]
Total subjects with adverse events	31 (13%)	23 (16%)	.344
Dyspnea[b]	16 (6.6%)	19 (14%)	**.028**
Dizziness not resolved within 60 sec of attaining upright position[b]	6 (2.5%)	0	.089
Tachycardia/bradycardia (change of ≥30 bpm or needed intervention)[b]	5 (2.1%)	1 (1.0%)	.420
Desaturation[b] (<85% or intervention required, ie, ↑ in Fio_2)[b]	4 (1.6%)	4 (3.0%)	.473
Nausea/vomiting[b]	3 (1.3%)	0	.300
Hypotension (<10 mm Hg from rest or needed intervention)[b]	2 (0.83%)	0	.533
Hypertension (>30 mm Hg from rest or needed intervention)[b]	1 (0.42%)	1 (1.0%)	>.999
Angina[b]	0	1 (1.0%)	.368
New arrhythmia (excluding sinus tachycardia and PVCs)[b]	0	0	N/A
Fall with or without staff assistance in lowering patient[b]	0	0	N/A
New numbness or tingling in any body part[b]	0	0	N/A
Blurred vision[b]	0	0	N/A
Cardiac arrest requiring CPR[c]	0	0	N/A
Death[c]	0	0	N/A
Required termination of treatment	8 (3.3%)	0	**.029**

Abbreviations: CPR, cardiopulmonary resuscitation; Fio_2, fraction of inspired oxygen; N/A, not applicable; PVCs, premature ventricular contractions.
[a]Values in boldface are statistically significant.
[b]Minor adverse event.
[c]Serious adverse event.

adverse events were defined as "undesirable, but non-life threatening, physiologic signs or symptoms during a PT or OT session." No serious adverse events were recorded in any group. Fifty-four subjects were reported to have at least 1 minor outcome (63 outcomes in total), but overall rates did not differ significantly between normal (n = 37, 15.5%) and abnormal K^+ (n = 26, 16.4%) groups. However, a greater rate of PT or OT session termination due to minor adverse events occurred in the normal K^+ group than in the groups with hyperkalemia (n = 12, 25.6%), hypokalemia (n = 14, 12.4%), and normokalemia (n = 37, 15.5%). Rates of adverse event by K^+ strata are shown in Table 3. Highest level of mobility achieved by K^+ strata is shown in Table 4.

DISCUSSION

The results of this study support the safe initiation of rehabilitation interventions for patients with serum K^+ levels of 3.1 to 5.9 mmol/L. No subjects included in this study experienced any serious adverse events. Rates of minor adverse events did not differ significantly between normal and abnormal K^+ groups; however, the specific cause for these events based on the data collected could not be determined.

Literature supports the association between abnormal serum K^+ levels and increased risk for cardiac events.[1,5,12,17] With increased myocardial demand brought about by increased activity level, K^+ concentrations should be a significant consideration for PTs and OTs when making clinical decisions about whether to initiate therapeutic intervention.[18] As far as we have found, this is the first study of its kind to investigate particular K^+ levels at which initiation of PT and OT services is safe. It was designed with the intention that all patients who have potential to benefit from PT and OT interventions receive appropriate treatments at appropriate times. We were aware that telemetry monitoring is not routinely used for all patients in an acute care setting with abnormal K^+ levels who may be at risk for developing arrhythmias. To address this concern, the subjects were monitored for signs and symptoms of arrhythmia (dizziness, dyspnea, blurred vision, significant change in heart rate or blood pressure, anginal pain, paresthesia, and nausea/vomiting),[18,20-22] and data from these patients were included. Age, gender, and acuity-level demographics were not collected for this group of participants, and analysis of these statistics is suggested for future research.

Individuals included in this study were noted to have a wide variety of comorbidities, and the effect

TABLE 4. Highest Level of Mobility Achieved

Highest Level of Mobility	Normal K^+ (N = 240)	Abnormal K^+ (n = 140)		
		Hypokalemia (N = 97)	Hyperkalemia (N = 43)	*P*
Nothing[a]	11 (4.6%)	0	2 (4.7%)	N/A
Sitting in bed[b]	5 (2.1%)	3 (3.1%)	1 (2.3%)	N/A
Sitting edge of bed <25% patient initiation[c]	6 (2.5%)	3 (3.1%)	2 (4.7%)	N/A
Sitting edge of bed with some trunk control[d]	12 (5.0%)	5 (5.2%)	4 (9.3%)	N/A
Standing[e]	16 (6.7%)	8 (8.2%)	4 (9.3%)	N/A
Transfer bed to chair[f]	32 (13.3%)	17 (17.5%)	6 (14.0%)	N/A
Marching in place[g]	3 (1.3%)	2 (2.1%)	1 (2.3%)	N/A
Walking[h]	153 (63.8%)	58 (59.8%)	23 (53.5%)	N/A

Abbreviation: N/A, not applicable.
[a]Passively rolled or exercised, splinted, raising head to upright.
[b]Sitting in bed/exercise in bed, active rolling, bridging, exercises, supine to sit, cycle ergometer, tilt table.
[c]Sitting edge of bed but with less than 25% initiation.
[d]Sitting edge of bed, actively sitting over side of bed with some trunk control (may be assisted).
[e]Standing: Weight-bearing through feet in standing position with or without assistance.
[f]Transfer bed to chair with standing, able to step or shuffle, and transferring weight from one leg to another to move to chair.
[g]Marching in place: Able to walk in place by lifting alternate feet at least 4 times with or without assistance.
[h]Walking: Walking away from bed/chair by at least 4 steps (2 for each foot) assisted or gait aid or unassisted.

and interaction between comorbidities in relation to serum K^+ levels could not be determined. Rates of these minor adverse events did not appear to be related to the difference between serum K^+ concentrations in this sample population. The effect of specific comorbidities on K^+ levels is not well understood in relation to activity and possible risk for developing potentially dangerous arrhythmias. Specific levels of mobility for patients with K^+ in specific ranges have not been studied. Further research is needed to determine the most appropriate guidelines for the provision of PT and OT intervention for patients with specific diagnoses and at differing exercise intensities in a population with varying K^+ levels.

Limitations

Comprehensive patient demographics were not collected for this subject sample, which limits the ability of the results of the study to be generalized. Telemetry monitoring was not available for all subjects, which required the researchers to rely on vital signs and symptoms for the detection of onset of new arrhythmia. Timing of blood draws and laboratory analysis of serum potassium levels was not accounted for in relation to potential electrolyte-balancing intervention (ie, intravenous administration of supplemental K+ or provision of sodium polystyrene sulfonate/Kayexalate) and PT or OT intervention. It is possible that the low rate of adverse events was confounded by the patient selection criteria. As acute care clinicians are already aware, the practicality of providing intervention only for patients who would meet the exclusion criteria for this study is not always realistic. This may warrant investigation of the safety of PT and OT intervention for patients with abnormal K^+ and stable hypo-/hypertension, and/or tachy-/bradycardia in future research.

CONCLUSION

This study suggests that PT and OT intervention in patients with serum K^+ levels of 3.1 to 5.9 mmol/L is safe. Subjects in an acute care setting, with and without telemetry monitoring, participated in therapeutic activities without any serious adverse events. Patients with K^+ levels of 3.1 to 5.9 mmol/L should not be excluded from receiving PT or OT services based solely on concern for cardiac arrhythmias related to this laboratory value.

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