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Impact of Hyperkalemia on Surgery Case Cancellation: A Call For Increased Reliability

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Abstract

Introduction: Hyperkalemia (HK) is known to be associated with increased risk of adverse outcomes related to anesthesia and surgery. The overall impact of hyperkalemia on surgery delay or cancellation is not known. This study was designed to assess the impact of HK on surgery case cancellation and to determine if any standards existed with respect to the management of surgical patients with HK in a large health system.

Methods: There were two phases of the study. Phase 1 was a structured survey was distributed to electronically to clinicians within the 26-hospital health system regarding HK knowledge and treatment paradigms. Phase 2 consisted of electronic health record data of patients treated between 1/1/2015-12/31/2020 who had an elevated serum K+ (> 5 mEq/L) ≤ 24 hours (an indication of preoperative HK) prior to a scheduled surgery.

Results: HK was clinically significant by 47% of respondents with a serum K+ level at 5.6-5.9 mEq/L and by 39% at K+ > 6 mEq/L thresholds. Only 50% of respondents recognized Renin-angiotensin-aldosterone system inhibitors as a risk factor for HK. Of 645,073 surgical cases 1.4% (n = 9,166) had a documented pre-operative HK. Black and Hispanic patients were more likely to have preoperative HK (≥ 6.0 mEq/L) compared to White (p = 0.01). Patients with a K+ value ≥ 6.0 mEq/L within 24 hrs. Of a scheduled surgery were 2.40 times more likely to have a cancelled surgery compared to patients with a K+ between 5.1-5.9 mEq/L (p < 0.0001).

Conclusion: There is a lack of consensus as to what constitutes significant preoperative HK, and whether to cancel or delay elective surgery due to HK, and no standard treatment when preoperative HK was identified. This study indicates a need for improved perioperative standards and greater reliability in the approach to surgical patients with HK.

Keywords

Hyperkalemia, Pre-operative assessment, Peri-operative medicine, Patient safety, Surgery cancellation, High reliability

Introduction

Hyperkalemia (HK) can have a significant adverse impact on patient care including increased frequency of emergency room visits, unplanned hospitalizations, urgent or emergent hemodialysis, and cancellation or delay of elective surgeries and procedures [1-3]. Hyperkalemia is typically asymptomatic but is known to increase the risk of potentially fatal cardiac irritability. Risk factors for HK include renal insufficiency and end stage renal disease (ESRD), drugs (such as renin-angiotensin-aldosterone system inhibitors) and heart failure, amongst others [4-7]. Not only do these events pose a significant risk for patients, but they may impact quality and can substantially increase the cost of care [8]. Preoperative hyperkalemia is considered a specific risk factor for peri-operative morbidity and mortality, that may result in delay or cancellation of surgery or other procedures requiring anesthesia [9-11]. Serum potassium (K) thresholds for postponing surgery vary from 5.5 to 5.9 mEq/L [11-14].

The impact of preoperative HK on surgeries and non-surgical procedures is presumed to be increasing because of the growing number of patients with kidney disease, especially ESRD. There are few studies in the literature that address the impact of preoperative HK on surgical care despite anecdotal evidence that anesthesiologists and surgeons encounter challenges managing ESRD patients in the peri-operative period. This study was designed to assess the impact of preoperative HK on surgery and surgical patient care. To the best of our knowledge, this is the largest analysis of the impact of preoperative HK on surgery and surgical patient care.

Methods

This study used mixed methods study design that included primary data collection from clinicians as well as retrospective analysis of electronic health record (EHR) data. The first stage comprised of a qualitative clinician survey (Phase I), followed by a quantitative retrospective patient cohort analysis using EHR data (Phase II). The protocol was reviewed by the local institutional review board (IRB) and deemed exempt.

Phase I

An anonymous structured survey was distributed to

clinicians within the Advocate Aurora Health (AAH) system regarding HK knowledge and treatment paradigms. The survey was distributed to clinicians, including emergency department (ED) physicians, surgeons, nephrologist, hospitalists, and anesthesiologist via a medical group newsletter (n = 9,168) or via a targeted email list (n = 2,119). Those in the targeted email distribution list who had not completed the survey within 14 days were sent a reminder by email (n = 2,032). Clinicians were only able to complete the survey once. The survey was constructed, distributed, and responses collected using REDCap® software. Clinician demographic and survey results were extracted from REDCap® and described using frequencies and percentages. The questionnaire is available upon request.

Phase II

Patients treated within the 26 Advocate Auroral Health (AAH) hospitals between 1/1/2015-12/31/2020 who had an elevated serum K^+ (> 5 mEq/L) ≤ 24 hours (an indication of preoperative HK) prior to a scheduled surgery were included in the study cohort (n = 9,166). All AAH laboratories use a common methodology and normalize values to ensure consistency across all facilities. There was no standard for the documentation of HK within 24 hours of scheduled elective surgery as a diagnosis within the medical record, therefore laboratory value alone was used for the purposes of this retrospective study. Demographic, surgery, pharmacy, and laboratory data were abstracted from AAH's integrated EHR system, Epic. Raw data was cleaned prior to analysis. Demographics, clinical characteristics, and comorbidities were calculated using medians, interquartile ranges (IQRs), frequencies, and percentages as appropriate. Means, standard deviations, and selected percentiles were used to describe serum K^+, c-reactive protein (mg/dL), and estimated glomerular filtration rate (eGFR) concentrations. Serum K^+ values were also dichotomized as 5.1-5.9 mEq/L and ≥ 6.0 mEq/L.

A time (hours) to K^+ lab decrease was computed as the difference in the time of the qualifying lab indicating HK and the first lab (≤ 24 hours) where potassium value dropped ≤ 5.0 mEq/L indicating attainment of normokalaemia. Patients were dichotomized if they received any HK treatment (including Kayexalate, Patiromer, Lokelma, and/or dialysis). Data was stratified and presented by HK diagnosis at time of surgery (yes/no). Bivariate analyses for surgery status (completed/cancelled), HK diagnosis at time of surgery (yes/no), initial potassium level (5.1-5.9/≥ 6.0 mEq/L), and hyperkalemia treatment (yes/no) included chi squared and Fisher's exact test for dichotomous variables and Wilcoxon sign rank test for continuous variables. Spearman correlation coefficients were calculated for continuous variables including K^+ lab values, time to K^+ level decrease (< 5.1 mEq/L), age, and Body Mass Index (BMI, kg/m^2).

Predictors of cancelled surgery (yes/no), HK diagnosis at time of surgery (yes/no), elevated K^+ (5.1-5.9 or ≥ 6.0), and receiving any HK treatment (yes/no) were evaluated using generalized estimating equations (GEE) with a binomial distribution and logit function. Clusters were introduced for multiple scheduled surgeries per patient. Final covariates were included if they were associated with exposure in our cohort, associated with exposure based on previous studies, and known to be a predictor of the outcome. All statistical analyses were carried out using SAS 9.4 (SAS Institute Inc., Cary, NC) and R version 4.0.

Results

Phase I

The response rate for the survey was low, 11% of the targeted list (237/2119). There was no way to discriminate responses originating from the newsletter vs. the targeted list. Demographic and patient characteristics for clinicians (n = 237) are shown in Table 1. Most respondents were male (66%) between the ages of 20-59 years of age and primarily Medical Doctors or Doctors of Osteopathy (99%). The most common work locations were surgery (33%) or ED (34%). Nearly half (47%) of respondents treat > 10 HK patients annually. HK was considered to be clinically significant by 47% of respondents with a serum K^+ level at 5.6-5.9 mEq/L and by 39% at K^+ > 6 mEq/L thresholds. Only 50% of respondents recognized Renin-angiotensin-aldosterone system inhibitors (RAASi) medications as a potential risk factor for HK, while chronic kidney disease (CKD) and acute kidney failure were selected most frequently (83% and 80%, respectively).

For those who work in surgery (surgeons and anesthesiologists), a K^+ of 5.4 mEq/L was the maximum level at which surgery under general anesthesia (88%) and monitored anesthesia care (MAC) (97%) is considered safe whereas physicians outside of surgery considered a maximum level of 6.0 mEq/L as safe. In the surgery survey, 57% felt that elevated K^+, if < 5.5, could be treated the day of surgery. Many (66%) felt that a K^+ > 5.5 mEq/L would result in a surgery cancellation whereas a K^+ > 5.0 mEq/L typically results in a surgery delay (51%). Vascular (34%) and general (30%) surgeries were reported to be most impacted by HK. Among the most prevalent treatment options for HK (IV fluids and diuretics, dialysis, and medications), most believed that pharmacologic agents having a shorter onset of action could reduce surgery cancellations and delays. Over half (52%) felt that a greater availability of pharmacological treatment options with faster onset of action would be of value in preventing cancellation of surgery.

Table 1: Demographic characteristics and general hyperkalemia opinions among clinicians (n = 237).

Demographic	n	%
Age[a]		
20-39	86	38
40-59	114	49
60-79	31	13
Gender[a]		
Female	75	33
Male	153	66
Other	3	1
Professional Degree[a]		
MD or DO	229	99
Advanced Practice Clinician	2	1
Primary Work Location[b,c]		
Surgery	75	33
Emergency Department	78	34
Internal Medicine or Family Practice	26	11
Hospital Medical or Surgical Unit	44	19
Nephrology/Dialysis	7	3
HK patient characteristic	n	%
Patients treated with HK as primary diagnosis (annually)[a]		
≤ 5	87	38
6-10	36	15
> 10	108	47
Serum K^+ (mEq/l) considered to be significant HK[a]		
4.5-5.5	33	14
5.6-5.9	108	47
≥ 6	90	39
Etiology of HK[b]		
Chronic Kidney Disease	197	83
Acute Kidney Failure	189	80
Dehydration	78	33
Iatrogenic	61	26
Medication use (e.g. RAAS inhibitors)	119	50
Internal bleeding	14	6
False lab value	112	47
Heart Failure	24	10
Hypertension	17	7
Diabetes	40	17

MD: Medical Doctor; DO: Doctor of Osteopathy; HK: Hyperkalemia; RAAS: Renin-angiotensin-aldosterone system; [a]n = 6 missing; [b]Respondents allowed to select > 1 answer

Phase II

Between 1/1/2015-12/31/2020 there were a total of 645,073 surgical cases identified within the AAH system. Of these, 1.4% (n = 9,166) consisted of 7,592 unique patients had preoperative HK as defined by serum K > 5 mEq/L. Some patients had more than one scheduled surgery during the study period (data not shown). Most patients in the cohort were older (mean = 67 years), overweight (average BMI = 28), and White (83%). Seven percent were Hispanic and 94% reported English as their primary language. Most patients were publicly insured (Medicare = 73%, and Medicaid = 11%) compared to privately insured (16%) (Table 2).

Of the 9,166 scheduled surgeries among patients with preoperative HK, 4% of surgeries were cancelled (n = 369). Surprisingly, although 7,592 patients had preoperative HK, only 13% (n = 1,000) had the diagnosis of HK in the Epic EHR. Serum K^+ values were slightly

Table 2: Demographic characteristics among patients with an elevated serum K+ ≤ 24 hours prior to an electively scheduled surgery.

	All (n = 7,592)	
	Median	**Interquartile range**
Age	67	(58, 77)
BMI (kg/m^2)	28	(24, 34)
	n	%
Gender		
Female	3,160	42
Smoking status		
Never	2,620	35
Ever	4,880	65
Race		
Black	983	13
Other	297	4
White	6,312	83
Ethnicity		
Hispanic/Latino	526	7
Primary language		
English	7,163	94
Spanish	266	4
Other	162	2
Insurance		
Medicaid	748	11
Medicare	4,942	73
Private	1,083	16

higher for those with an HK diagnosis (median = 5.7 mEq/L) compared to those without an HK diagnosis (median = 5.3 mEq/L). C-reactive protein values were also higher for those with a HK diagnosis (median = 7.2 mg/dL) compared to those without a HK diagnosis (median = 6.5 mEq/L). Patients without an HK diagnosis had slightly better kidney function with an average estimated glomerular filtration rate (eGFR) of 39.4 mg/min compared to those with a HK diagnosis (mean = 29.5 mg/min). Among patients with documentation of repeat K^+ measurement during the encounter, it took approximately nine hours for the serum K^+ to drop < 5.1 mEq/L. The average time to achieve a serum K^+ < 5.1 mEq/L was similar for those taking oral medications (mean = 11 hours) compared to those who underwent dialysis (mean = 12 hours).

Predictors of cancelled surgery

Patients with a K^+ value ≥ 6.0 mEq/L within 24 hrs. of a scheduled surgery were 2.40 times more likely to have a cancelled surgery compared to patients with a K^+ between 5.1-5.9 mEq/L (odds ratio (OR): 2.40, 95% confidence interval (CI): 1.96, 3.10, p < 0.0001). Patients who received any HK treatment were 33% more likely to have a cancelled surgery (OR: 1.33, 95% CI: 1.00, 1.76, p = 0.04). Patients with an acute kidney failure diagnosis were also 38% more likely to have a cancelled surgery compared to those without the diagnosis (OR: 1.38, 95% CI: 1.13, 1.69, p = 0.002).

Table 3: Predictors of receiving HK treatment among patients with an elevated K+ ≤ 24 hours prior to a scheduled surgery (n = 9,166).

		Unadjusted			Adjusted		
Predictor	**N (%)**	**OR**	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**
K^+ ≥ 6.0[q]	317 (3)	0.79	(0.76, 82)	< 0.001	0.79	(0.76, 0.82)	< 0.0001
Female	465 (5)	1.00	(0.98, 1.01)	0.92	1.00	(0.98, 1.01)	0.86
Ever a smoker	759 (8)	1.01	(0.99, 1.02)	0.57	1.01	(0.99, 1.02)	0.31
Black[a]	208 (2)	0.99	(0.97, 1.01)	0.35	1.00	(0.98, 1.02)	0.73
Hispanic[q]	119 (1)	0.95	(0.92, 0.98)	0.01	0.98	(0.94, 1.00)	0.06
Spanish as primary language	58 (1)	0.98	(0.96, 1.01)	0.12	0.99	(0.97, 1.02)	0.63
Public health insurance	874 (10)	1.00	(0.99, 1.02)	0.65	1.01	(0.99, 1.02)	0.48
Acute Kidney Failure[a]	459 (5)	0.96	(0.94, 0.97)	< 0.0001	0.99	(0.97, 1.00)	0.14
Albuminuria[a]	176 (2)	0.95	(0.92, 0.97)	0.0002	0.98	(0.96, 1.02)	0.43
Anemia	224 (2)	0.92	(0.89, 0.95)	< 0.0001	0.97	(0.94, 0.99)	0.04
CKD[a,b]							
Stages 1-5, unspecified	633 (7)	1.08	(0.07, 1.10)	< 0.0001	1.06	(1.04, 1.08)	< 0.0001
ESRD	74 (1)	1.20	1.12, 1.29)	< 0.0001	1.19	(1.11, 1.27)	< 0.0001
Diabetes[a]	624 (7)	0.96	(0.94, 0.97)	< 0.0001	1.00	(0.98, 1.01)	0.66
Hypertension[a]	853 (9)	0.97	(0.96, 0.99)	0.002	1.01	(1.00, 1.03)	0.11

Models adjusted for elevated K^+ (< 6.0, ≥ 6.0), race (Black, White), Hispanic (yes, no) , Acute kidney failure diagnosis (yes, no); Albuminuria (yes, no), Anemia (yes, no), CKD (stages 1-5, unspecified, ESRD, no CKD), Diabetes (yes, no) and hypertension (yes, no); [q]Models adjusted for all covariates except main predictor variable; HK treatments include: Kayexalate, Patiromer, Lokelma, or dialysis; [b]CKD reference: no CKD

Predictors of preoperative HK

Black patients were more likely to have preoperative HK (≥ 6.0 mEq/L) compared to White patients (OR = 1.27, 95% CI: 1.07, 1.50; p = 0.01). Overall, Hispanic patients were 24% more likely to have preoperative HK in unadjusted models (OR: 1.24, 95% CI: 1.02, 1.54, p = 0.04), though not statistically significant in adjusted models. Patients with a hypertension diagnosis were 18% less likely to have preoperative HK (OR: 0.82, 95% CI: 0.72, 0.93, p = 0.003).

Predictors of receiving treatment for HK

Predictors of receiving HK treatment (including Kayexalate, Patiromer, Lokelma, or dialysis) are described in Table 3. Ironically, those with a $K^+ \geq 6.0$ mEq/L were less likely to receive HK treatment (OR: 0.97, 95% CI:0.76, 0.82, p < 0.0001). Patients with an anemia diagnosis were also less likely to receive any hyperkalemia treatment (OR = 0.97, 95% CI: 0.94, 0.99; p = 0.04). Patients with CKD (1-5 and unspecified), and ESRD were more likely to received HK treatments (OR = 1.06, 95% CI: 1.04, 1.08; p < 0.0001 and OR = 1.19, 95% CI: 1.11, 1.27; p < 0.0001, respectively).

Discussion

Significant elevations of serum potassium can have an adverse impact on the reliability and quality of surgical patient care as well as on patient experience when hyperkalemia is encountered perioperatively; consequently, anesthesiologists, surgeons, and the entire healthcare team need to have strategies to effectively manage HK to ensure optimal patient outcomes. Although there are isolated reports of safely operating on patients with HK, they are typically restricted to patients with chronic renal failure undergoing a vascular access procedure under regional anesthesia [2]. The most robust data regarding the risk of HK is published with respect to hospitalized patients in general, and the relationship between HK and increased morbidity and mortality is well established [12-17].

Our study survey results indicate that most (88%) of anesthesiologists and surgeons agree that a pre-operative serum $K^+ \geq 5.5$ mEq/L is an indication to delay or cancel surgery. Interestingly, most non-surgical physicians believed it was safe to proceed unless the $K^+ > 6$ mEq/L. We have no data that explains this discrepancy. If anything, this difference, and inconsistency in opinion reflects the challenge of establishing and maintaining high reliability in healthcare. The lack of consistency in varying opinion of physicians with respect to HK may illustrate a significant difference in understanding and interpretation of the risk of HK, which can lead to conflicting patient care and messaging. The indications for surgery and urgency might influence clinical decision-making, but that occurs at the individual patient level. Our survey only considered global thresholds for the definition of HK and associated risk.

With respect to underlying etiology, only 50% of respondents recognized RAASi medications as a potential contributor to HK. These results indicate an opportunity for improved reliability and more consistent standards in pre-surgical evaluation and patient optimization, and a need for education regarding the importance of recognizing and addressing risk factors related to HK pre-operatively. Our findings are consistent with the conclusions of other authors regarding the inconsistency of perception of the risk of abnormal potassium and surgery [18-20].

Many patients with co-morbidities such as diabetes mellitus, chronic kidney disease, septicemia, and heart failure are prone to develop hyperkalemia [9,10,15]. Today, many surgical patients are taking medications like angiotensin converting enzyme (ACE) inhibitors, angiotensin receptor blockers (ARBs), and aldosterone antagonists all of which can increase the risk of developing perioperative hyperkalemia and associated complications [9,17,21]. In addition to patient risk factors, consequences of surgery and anesthesia, for example intraoperative tissue damage, extensive tissue dissection, blood transfusion and suxamethonium, may cause intraoperative hyperkalemia in high-risk patients [19].

In the operating room setting, HK can result in serious or life-threatening cardiac arrhythmias. The patients most at risk are those with renal insufficiency and especially ESRD. Patients identified most at risk typically have serum potassium checked immediately prior to surgery and if HK is identified, the surgery may be cancelled and rescheduled. However, our data demonstrates the only a small percentage (10%) of patients having a serum $K^+ \geq 5.5$ mEq/L had their surgeries cancelled. This implies that anesthesia and surgical teams may be willing to accept increased risk for elective cases, but that this acceptance of increased risk is unpredictable. We found no evidence that patients were treated differently with respect to the increased risk associated with HK. Although there is no clear-cut point regarding serum potassium level for the purpose of postponing the surgery or proceeding with the surgery, it has been observed that the patients with a preoperative serum potassium level > 5.5 mEq/L are twice as likely to require intraoperative management for hyperkalemia as compared to the patients with a preoperative serum potassium level < 5.5 mEq/L [9,10].

During the study period, 1.4% of patients scheduled for elective surgery had a serum $K^+ \geq 5.5$ mEq/L documented within 24 hours of surgery. Of these, 369 had their surgery cancelled. The reasons that some HK patients had their surgery cancelled while others

proceeded is not explained within the medical record. Most patients did *not* have surgery cancelled. This study did not address the reasons for cancelling or proceeding with surgery despite HK. The lack of consistency is troubling, especially since only elective surgeries are included in this study. Our findings can be interpreted as indicating that physicians are willing to accept differing levels of risk in an unpredictable fashion. This is not consistent with high reliability concepts, and further leads to the conclusion that there is no standard of care with respect to preoperative HK. Furthermore, we could not identify any evidence that patients were consented differently with respect to the increased risk of proceeding with surgery in the face of HK.

An unexpected finding of the study was the unreliability of the electronic health record in identifying patients with HK. To identify our study cohort, we relied on laboratory data, cross referenced with documented diagnoses in each patient's EHR. It is notable that only 10% of patients with documented serum $K^+ \geq 5.5$ mEq/L had the diagnosis of HK in the health system Epic EHR. The implications of this finding are many, whether from the perspective of the need for improved documentation or the difficulty in accessing the veracity of datasets derived from electronic health records.

The current treatment for hyperkalemia, although not standardized, involves 3 different modalities: Cardiac membrane stabilization, intracellular shift of potassium, and potassium elimination [20-22]. For emergent, life-threatening HK, hemodialysis is necessary. For non-life threatening, but clinically significant HK, there are two primary approaches for treatment: Oral potassium binders or hemodialysis. Because hemodialysis is expensive and may be logistically difficult to institute, oral therapy is generally preferred in the non-emergent setting [23]. Calcium gluconate, or calcium chloride can be used in the emergent setting for cardiac membrane stabilization to prevent arrythmias caused by hyperkalemia, but its duration of action is limited to 30-60 minutes [24]. Insulin, and beta blockers can be used to shift potassium intracellularly, but insulin administration can result in hypoglycemia, does not lower the total body K^+ concentration, and duration of effect is only 4-6 hours [25]. Loop diuretics can be used to increase urinary potassium excretion, but no randomized controlled trials have been done to assess efficacy. Furthermore, given the prevalence of renal disease, the effectiveness of loop diuretics at the individual patient level is variable.

Sodium polystyrene sulfonate (SPS), a conventional potassium binder agent, is traditionally the most used oral treatment for HK, however it can take 6 hours or longer to effectively reduce serum K and has been associated with increased risk of serious gastrointestinal complications such as ischemia, thrombosis, and perforation, which limit its use in patients immediately prior to surgery [26]. In contrast, newer oral potassium binders like sodium zirconium cyclosilicate (SZC) and patiromer calcium sorbitex have demonstrated efficacy and safety and a lower side-effect profile than SPS in randomized clinical trials [23,27,28]. All are supplied as a powder and mixed with water. The standard does of SZC is mixed with approximately 3 tablespoons of water. Compared to SPS, SZC contains less sodium per dose (400 mg vs. 1,500 to 3,000 mg) and is also more palatable (tasteless). In addition, SZC has a more rapid onset of action, and clinically significant reductions in K^+ can be seen in as early as 1 hour [4].

If surgery is to be delayed instead of cancelled due to HK, the time necessary to reduce serum K to a safe level is important. A study comparing insulin + glucose treatment combined with sodium zirconium vs. insulin + glucose with a placebo, did not show a significant serum K difference at one hour, but did demonstrate incremental improvement at 2 hours, which may be due to its effect in the proximal small intestine, highlighting a relatively rapid onset of action [29]. If patients with HK could be treated using potassium binders pre-operatively, then they might be able to have surgery the same day, following a slight delay.

Increasing reliability and safety mandate that preoperative screening protocols would identify high risk patients and could then be used to direct oral treatment of HK prior to surgery avoiding exposing the patient to unnecessary increased risk, delay, or cancellation of the surgical procedure. The results of this study indicate a lack of consistency in the management of surgical patients known to have HK indicating a need for quality improvement.

To the best of our knowledge, this is the largest study of preoperative HK, however, our study is not without limitations. Our response rate for the clinician survey was low, and its possible those who completed the survey may have different clinical opinions regarding HK compared to those who did not fill out the survey. However, our follow-up indicated that those completing the survey were clinicians most familiar with the challenges occurring due to HK. Although we captured routine HK treatments, we were unable to associate intravenous fluid orders directly to treatment of HK which may have contributed to residual confounding when modeling outcomes. Finally, some of our unexpected results could be a result of unmeasured confounding data not captured discretely from the EHR. Surgery details documented in the EHR were limited to completion or cancellation and data on additional adverse events in the patient record would have provided more insight. Finally, we were only able to capture in-patient dialysis treatments because outpatient dialysis is not recorded in the EHR.

Conclusion

There is lack of consensus as to what K value constitutes significant preoperative HK. Similarly, there is a lack of consensus regarding whether to cancel or delay elective surgery due to HK, and no standard treatment when preoperative HK is identified. The inconsistency in accepting increased perioperative risk due to HK indicates a lack of high reliability in patient care. This data indicates a need for improved perioperative standards and greater reliability in the approach to surgical patients with HK.

Disclosure

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