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Prevalence and Prognosis of Hyperkalemia in Patients with Acute Myocardial Infarction

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Abstract

Background—Hyperkalemia is common and potentially dangerous in hospitalized patients; its contemporary prevalence and prognostic importance following acute myocardial infarction are not well described.

Methods—In 38,689 consecutive acute myocardial infarction patients from the Cerner Health Facts database, we evaluated the association between maximum in-hospital potassium levels (max K) and in-hospital mortality. Patients were stratified by dialysis status, and grouped by max K as follows: <5 mEq/L, 5–<5.5 mEq/L, 5.5–<6.0 mEq/L, 6.0–<6.5 mEq/L, and ≥ 6.5 mEq/L.

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Multivariable logistic regression was used to adjust for multiple patient and site characteristics. The relationship between number of hyperkalemic values and in-hospital mortality was also evaluated.

Results—Of 38,689 acute myocardial infarction patients, 886 were on dialysis. The rate of hyperkalemia (max K ≥ 5.0 mEq/L) was 22.6% in non-dialysis and 66.8% in dialysis patients. Moderate-severe hyperkalemia (max K ≥ 5.5 mEq/L) occurred in 9.8% of patients. There was a steep increase in mortality with higher max K levels. In-hospital mortality exceeded 15% once max K ≥5.5 mEq/L regardless of dialysis status. The relationship between higher max K and increased mortality risk persisted after multivariable adjustment. In addition, patients with greater number of hyperkalemic values (vs. a single value) experienced higher in-hospital mortality.

Conclusions—Hyperkalemia is common in patients hospitalized with acute myocardial infarction. Higher max K levels and number of hyperkalemic events are associated with a steep mortality increase; with higher risks for adverse outcomes observed even at mild levels of hyperkalemia. Whether more intensive management of hyperkalemia may improve outcomes in acute myocardial infarction patients merits further study.

Keywords

Hyperkalemia prevalence; Acute myocardial infarction; Dialysis

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Hyperkalemia is a common electrolyte abnormality that can lead to serious and potentially fatal cardiac dysrhythmias.[1] Prior work has consistently supported the link between hyperkalemia and adverse cardiovascular outcomes.[1–3] In the modern era, the prevalence of chronic kidney disease and diabetes, both associated with hyperkalemia, is rising.[4,5] Additionally, there has been widespread adoption of practices that increase the risk of hyperkalemia in acute myocardial infarction survivors with or without incident heart failure. Examples of such therapies include guideline-directed use of beta-blockers[5], mineralocorticoid receptor antagonists[6], and renin angiotensin aldosterone system antagonists.[7–9] The increase in the use of these medications has been associated with significant increases in hyperkalemia-related hospitalization and deaths.[7,8,10] Further, procedures such as percutaneous intervention and coronary artery bypass grafting, are common in the contemporary management of acute myocardial infarction, and may indirectly contribute to the risk of hyperkalemia via the associated incidence of contrast-induced nephropathy[11] and acute kidney injury[12], respectively.

While prior studies have examined the U-shaped relationship between serum potassium levels and mortality following acute myocardial infarction[1], neither the contemporary prevalence nor prognostic importance of various degrees of hyperkalemia have been described. In addition, it is unclear whether or not resolution of hyperkalemia results in improved outcomes. Further defining the risk associated with hyperkalemia in general, as well as with varying degrees of hyperkalemia, could help identify patients who may derive the greatest benefit from more aggressive hyperkalemia management. Accordingly, we analyzed data from Cerner Health Facts, a database of patients hospitalized with acute myocardial infarction in the United States between 2000–2008, to (1) examine the prevalence and prognosis associated with hyperkalemia in patients hospitalized for acute myocardial infarction, according to dialysis status; (2) describe mortality outcomes based on persistence versus resolution of hyperkalemia; and (3) evaluate mortality outcomes based on the number of recorded hyperkalemia events.

METHODS

Study Design and Participants

Details regarding the Health Facts® registry have been previously described.[1,13] Briefly, Cerner Corporation's Health Facts acute myocardial infarction database is a 67-center registry of 39,759 consecutive patients with acute myocardial infarction hospitalized between January 1, 2000 and December 31, 2008. Data collected included patients' demographic characteristics, medical history, comorbidities (using the International Classification of Diseases-Ninth Revision-Clinical Modification [ICD-9-CM], codes), laboratory studies, medications, procedures, and complications.

We queried the Health Facts database using ICD-9 codes. Documentation of acute myocardial infarction required a primary discharge diagnosis of acute myocardial infarction, using *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) diagnostic codes 410.xx, along with positive cardiac biomarkers. For this analysis, we included 38,689 patients with biomarker-confirmed acute myocardial infarction who also had at least 1 recorded potassium value (Figure 1). We included patients who had only whole blood potassium measurements recorded as we used serum potassium values for this analysis. Patients excluded from analysis were those admitted from hospice or transferred from a critical access hospital and those with a length of stay over 31 days. Data in the Health Facts database were obtained from patients' electronic medical records and included demographic (age, sex, and race) and clinical information (medical history, in-hospital procedures documented by *ICD-9-CM* codes), comprehensive laboratory data (including all in-hospital potassium measurements), pharmacy data, in-hospital mortality and hospital characteristics. All data were de-identified before being provided to the investigators; thus this analysis was considered exempt from human subjects research review by the Saint Luke's Hospital Institutional Review Board.

Definition of Hyperkalemia

Hyperkalemia was defined as at least one maximum in-hospital potassium level measurement equaling 5 mEq/L or greater. Moderate-severe hyperkalemia was defined as a maximum potassium level equal to or greater than 5.5 mEq/L.

Inpatient Serum Potassium Measurements and Outcomes

The Health Facts database included all acute myocardial infarction patients' serum potassium levels and their time of measurement relative to hospital admission. The maximum serum potassium level was defined as the highest potassium level at any point during hospitalization. Our primary focus was the relationship between maximum in-hospital potassium levels and outcomes. All serum potassium values were measured and reported in mEq/L (1 mEq/L = 1 mmol/L).

The primary outcome for this analysis was in-hospital mortality stratified by dialysis status, as documented in the Health Facts database. In secondary analyses, we examined in-hospital mortality according to number of hyperkalemia values (1 vs. 2 vs. 3 or greater). We subsequently evaluated mortality based on whether or not potassium normalized following the highest measurement. We defined normalization as a mean potassium level of less than 5.0 mEq/L following the maximum in-hospital potassium measurement, while non-normalization was defined as a mean potassium level greater than or equal to 5 mEq/L following the maximum in-hospital potassium measurement.

Statistical Analysis

Baseline demographics and clinical characteristics were compared among patients categorized by the maximum in-hospital serum potassium levels: less than 5.0, 5.0 to less than 5.5, 5.5 to less than 6.0, 6.0 to less than 6.5, 6.5 or greater mEq/L. Continuous characteristics were compared using a linear trend test while categorical variables were compared using the Mantel-Haenszel trend test. Hierarchical logistic regression was then used (with hospital site as a random effect to account for clustering across centers) to assess the independent association between maximum serum potassium levels and mortality, after adjustment for potential patient- and hospital-level confounders.

Patients were stratified by dialysis status, and grouped into categories of max K (<5 mEq/L [reference group], 5–<5.5 mEq/L, 5.5–<6.0 mEq/L, 6.0–<6.5 mEq/L, and ≥ 6.5 mEq/L). For the multivariable models, predictor variables were chosen *a priori* based on factors previously shown to be associated with in hospital mortality. Covariates included in our main model assessing the association of mortality with hyperkalemia in non-dialysis dependent patients included age, sex, and race; baseline comorbidities captured by *ICD-9-CM* codes (diabetes, heart failure, hypertension, cerebrovascular disease, peripheral vascular disease, lung disease, dementia); other laboratory values on admission (glucose, white blood cell count, hematocrit, glomerular filtration rate); peak cardiac troponin level (a marker of infarct size); number of potassium checks per patient; cardiogenic shock and acute respiratory failure on admission (determined by *ICD-9-CM* codes); in-hospital procedures captured by *ICD-9-CM* codes (cardiac catheterization, percutaneous coronary intervention, and coronary artery bypass graft surgery); in-hospital complications (acute kidney injury defined by the Acute Kidney Injury Network as an increase in serum creatinine from laboratory (not ICD-9-M codes) by ≥0.3 mg/dL from baseline, or a relative increase in serum creatinine of ≥50%, during hospitalization); length of hospital stay; and medications during hospitalization (fibrinolytic therapy, aspirin, clopidogrel, ticlopidine, β-blockers, angiotensin-converting enzyme [ACE] inhibitors or angiotensin II receptor blockers, calcium channel blockers, nitrates, diuretics, bronchodilators, statins, insulin treatment, and oral antihyperglycemic agents).

For the model evaluating relationship of dialysis dependence and in-hospital mortality stratified by potassium level, the covariates included were nearly identical to those used in the main model, except we did not include acute kidney injury or initial glomerular filtration rate.

In secondary analyses, we examined crude mortality rate according to the number of hyperkalemic values (1 vs. 2 vs. 3 or greater). Next, we examined crude in-hospital mortality rates according to whether or not the potassium levels normalized following the highest potassium measurement using *Chi* square test. Additionally, a multivariable logistic regression model was constructed to examine the relationship between post-maximum potassium level normalization in patients with hyperkalemia and in-hospital mortality. For this model, we used the same covariates as those included in the logistic model evaluating the relationship of categories of hyperkalemia and in-hospital mortality. Lastly, we used a sensitivity analysis to evaluate the association between varying degrees of hyperkalemia and in-hospital mortality after excluding patients who died within 24 hours of admission.

Missing baseline data (mean number of missing items per patient= 0.34) were imputed using IVEware (Imputation and Variance Estimation Software; University of Michigan's Survey Research Center, Institute for Social Research, Ann Arbor, MI). All remaining analyses were conducted using SAS v9.3 (SAS Institute, Inc., Cary, NC), and statistical significance was determined by a 2-sided p-value of <0.05.

RESULTS

Study Population

Of 38,689 acute myocardial infarction patients in our analytic cohort, 886 (2.3%) were on prior maintenance dialysis. The median number of acute myocardial infarction patients from each hospital was 219 (interquartile range [IQR]: 48 to 1030). The 67 hospitals that contributed data to this analysis were comparable in their characteristics to those reported in other national registries: they were most commonly urban centers (88.5%), were less frequently teaching hospitals (35.9%), and represented all geographic regions of the United States (Northeast 38.5%, Midwest 25.6%, South 26.9%, and West 9%).

Hyperkalemia Prevalence and Prognosis

The prevalence of any hyperkalemia (max K >5 mEq/L) in the overall cohort was 23.6%, while moderate-severe hyperkalemia (max K ≥ 5.5 mEq/L) occurred in 9.8% of patients. The median number of potassium measurements per patient with hyperkalemia was 8.0 (IQR, 4.0–14.0) vs. 3.0 (IQR, 2.0–6.0) in patients without hyperkalemia. The median length of stay for patients with hyperkalemia was 7.3 days (IQR, 4.2–11.6) vs. 3.8 days (IQR, 2.5–6.0) in patients without hyperkalemia. A maximum potassium level of 5 mEq/L or greater occurred in 66.8% of patients who were dialysis-dependent and in 22.6% of patients who were not dialysis-dependent. Moderate-severe hyperkalemia occurred in 41.0% and 9.1% who were and were not dialysis-dependent, respectively. Patients with higher maximum potassium levels were older and had a greater burden of comorbidities including higher burden of heart failure, lung disease and acute kidney injury and any renal disease. They also had lower median estimated glomerular filtration rate, lower hemoglobin, and higher glucose and peak troponin levels (Table 1).

There was a steep increase in mortality with higher maximum potassium levels; this relationship was linear in non-dialysis patients, while a plateau was observed in dialysis patients (Figure 2). In the overall cohort, patients with higher max potassium levels experienced higher in-hospital mortality rates, as follows: 4.2%, 11.1%, 16.6%, 26.6%, 31.7% (p value for trend <0.001) for maximum potassium categories <5, 5 – <5.5, 5.5 – <6.0 mEq/L, 6 – <6.5 mEq/L, ≥6.5 mEq/L, respectively. The relationship between maximum potassium and mortality persisted within each dialysis subgroup after multivariable adjustment. Adjusted odds ratios (OR) for in-hospital mortality based on maximum potassium of 5 – <5.5, 5.5 – <6.0 mEq/L, 6 – <6.5 mEq/L, ≥6.5 mEq/L versus <5 mEq/L were 2.03 (95% CI 1.79–2.31), 2.79 (2.35–3.31), 4.62 (3.74–5.71), 4.97 (3.96–6.25) respectively for patients who were dialysis-dependent. The odds for in-hospital mortality among non-dialysis patients, in comparison to a reference potassium value of <5 mEq/L were 1.62 (1.41–1.87), 2.02 (1.68–2.43), 3.18 (2.51–4.03), 3.37 (2.60–4.36). In a sensitivity analysis excluding patients that died within 24 hours of admission from the primary model, we found that in the odds of in-hospital mortality rates were similar to those of the primary model (data not shown).

In-hospital mortality according to potassium normalization

Of all patients with any hyperkalemia and at least one potassium measurement following the maximum potassium level (n=7549), 6788 experienced potassium normalization to <5 mEq/L, and 761 patients' levels did not. Following multivariable adjustment, patients whose potassium level did not normalize were found to have greater than twice the odds of in-hospital mortality (OR 2.22, 95% CI 1.74–2.78) as compared with those whose potassium levels did normalize.

Mortality according to number of hyperkalemia values

Among patients with in-hospital hyperkalemia, the mortality rate was 13.4% for patients with a single measurement of potassium ≥5 mEq/L, while it was 16.2% in patients who had 2 potassium measurements of a level of ≥5 mEq/L, and 19.8% in patients with 3 or more potassium measurements ≥5 mEq/L.

DISCUSSION

In this large multicenter, contemporary cohort with acute myocardial infarction, we found that hyperkalemia occurred in approximately twenty percent of non-dialysis patients and sixty five percent of dialysis patients. There was a graded mortality increase with higher maximum potassium levels, particularly in non-dialysis patients; and with greater number of hyperkalemia values. Furthermore, in-hospital mortality risk was more than double among patients with hyperkalemia whose potassium levels remained persistently hyperkalemic versus those whose levels normalized during hospitalization. To our knowledge, our study is among the first to describe the prevalence of hyperkalemia, and the steep increase in-hospital mortality associated with hyperkalemia in patients hospitalized with acute myocardial infarction who are and are not dependent on renal replacement therapy.

Prior Studies

Reports of the prevalence of hyperkalemia in cardiovascular diseases have thus far been variable. In a large cohort of patients hospitalized with acute myocardial infarction, Goyal *et* *al* examined the association of potassium levels with in-hospital ventricular arrhythmias, cardiac arrest, finding an increase in the risk of in-hospital death among those with potassium levels of 5.5 mEq/L.[1] Serum potassium levels in the high-normal or mildly elevated range (4.5 – 5.5 mEq/L) were also associated with significantly increased mortality.[1,14] An older prior study included 1074 patients with acute myocardial infarction and demonstrated a U-shaped relationship between potassium levels and early postinfarction ventricular fibrillation events, but lacked power to show an association between potassium level and mortality, and was performed in the era preceding current advancement in acute myocardial infarction management.[15]

Several studies have reported increased hyperkalemia trends associated with widespread adoption of medications including angiotensin converting enzyme inhibitors[16], aldosterone receptor blockers[17], spironolactone[7,18]. Our study extends prior work by describing mortality according to varying degrees of hyperkalemia, as well as examining outcomes stratified by the number of hyperkalemia values and normalization (versus persistence) of hyperkalemia.

Clinical implications

Recognition of hyperkalemia is especially important in patients with cardiovascular disease, such as those with acute myocardial infarction. Our findings highlight the frequency of hyperkalemia following acute myocardial infarction. Though treatment effect was not evaluated in this analysis, it is noteworthy that resolution of hyperkalemia does portend a better prognosis than persistent hyperkalemia. We feel that the poor prognosis associated with hyperkalemia should prompt clinicians to evaluate their patients for potentially modifiable factors that are associated with hyperkalemia following acute myocardial infarction.. In terms of hyperkalemia management, the few more traditional approaches to pharmacologic management of hyperkalemia, including intravenous insulin and sodium bicarbonate, have conflicting data supporting their efficacy. Several new products are in development, including patiromer calcium and sodium zirconium cyclosilicate (ZS-9).[19–21] Phase 3 clinical trials have been recently completed in outpatients with chronic kidney disease and hyperkalemia. Although these novel treatment modalities may ultimately change the way hyperkalemia is managed in the hospital, they are still undergoing investigation in the acute and outpatient settings. Our study is particularly timely in light of development of new medications for the management of hyperkalemia, and highlights an opportunity to investigate the heterogeneity of treatment benefit of these agents. Furthermore, whether more aggressive treatment of hyperkalemia will improve patient outcomes is still unknown, and requires further study.

Limitations of the study

Our study findings should be considered in the context of several potential limitations. We recognize that hemolysis can contribute to hyperkalemia and that rates of hemolysis are higher in initial emergency room phlebotomy specimens compared to those taken later when in hospital. However, should a significant number of pseudohyperkalemic events have occurred due to hemolysis, we feel that this would have biased our results toward the null. In terms of the analysis, first, because of the observational nature of our analyses, we cannot rule out the possibility of residual confounding despite adjustment for numerous potential confounders. Therefore, our data cannot be used to determine whether hyperkalemia is a marker or mediator of adverse outcomes, particularly if the peak K occurred around the time of a patient's death. Second, we did not evaluate hyperkalemia treatment interventions in this study, so no inference could be made regarding the cause of normalization (or lack thereof) of hyperkalemia. Last, our study focused on in-hospital mortality; and did not examine the relationship between hyperkalemia and other outcomes.

Conclusions

Our findings reveal that hyperkalemia is very common in patients hospitalized with acute myocardial infraction, and associated with marked increases in mortality, even with mild potassium elevations – both in patients with and without end-stage renal disease. Furthermore, patients with more frequent and persistent hyperkalemia experience higher in-hospital mortality as compared to those with transient potassium elevations. These results should prompt further investigation to determine whether more aggressive management of hyperkalemia can improve outcomes in patients hospitalized with acute myocardial infarction.

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REFERENCES

1. Goyal A, Spertus JA, Gosch K, et al. Serum potassium levels and mortality in acute myocardial infarction. Jama. 2012 Jan 11; 307(2):157–164. [PubMed: 22235086]
2. An JN, Lee JP, Jeon HJ, et al. Severe hyperkalemia requiring hospitalization: predictors of mortality. Critical care (London, England). 2012; 16(6):R225.
3. McCullough PA, Beaver TM, Bennett-Guerrero E, et al. Acute and chronic cardiovascular effects of hyperkalemia: new insights into prevention and clinical management. Reviews in cardiovascular medicine. 2014; 15(1):11–23. [PubMed: 24762462]
4. Services USDoHaH. National Diabetes Statistics Report: Estimates of Diabetes and Its Burden in the United States. Centers for Disease Control and Prevention. 2014 [web page]. 2014.
5. Weir MA, Juurlink DN, Gomes T, et al. Beta-blockers, trimethoprim-sulfamethoxazole, and the risk of hyperkalemia requiring hospitalization in the elderly: a nested case-control study. Clinical journal of the American Society of Nephrology : CJASN. 2010 Sep; 5(9):1544–1551. [PubMed: 20595693]
6. Pitt B, Bakris G, Ruilope LM, DiCarlo L, Mukherjee R. Serum potassium and clinical outcomes in the Eplerenone Post-Acute Myocardial Infarction Heart Failure Efficacy and Survival Study (EPHESUS). Circulation. 2008 Oct 14; 118(16):1643–1650. [PubMed: 18824643]

7. Juurlink DN, Mamdani MM, Lee DS, et al. Rates of hyperkalemia after publication of the Randomized Aldactone Evaluation Study. The New England journal of medicine. 2004 Aug 5; 351(6):543–551. [PubMed: 15295047]
8. Wozakowska-Kaplon B, Janowska-Molenda I. Iatrogenic hyperkalemia as a serious problem in therapy of cardiovascular diseases in elderly patients. Polskie Archiwum Medycyny Wewnetrznej. 2009 Mar; 119(3):141–147. [PubMed: 19514643]
9. Perazella MA. Drug-induced hyperkalemia: old culprits and new offenders. The American journal of medicine. 2000 Sep; 109(4):307–314. [PubMed: 10996582]
10. Fordjour KN, Walton T, Doran JJ. Management of hyperkalemia in hospitalized patients. The American journal of the medical sciences. 2014 Feb; 347(2):93–100. [PubMed: 23255245]
11. McCullough PA, Soman SS. Contrast-Induced Nephropathy. Critical Care Clinics. 2005; 21(2): 261–280. [PubMed: 15781162]
12. Garovic VD, Textor SC. Renovascular Hypertension and Ischemic Nephropathy. Circulation. 2005 Aug 30; 112(9):1362–1374. 2005. [PubMed: 16129817]
13. Salisbury AC, Reid KJ, Marso SP, et al. Blood Transfusion During Acute Myocardial Infarction Association With Mortality and Variability Across Hospitals. Journal of the American College of Cardiology. 2014; 64(8):811–819. [PubMed: 25145526]
14. McMahon GM, Mendu ML, Gibbons FK, Christopher KB. Association between hyperkalemia at critical care initiation and mortality. Intensive care medicine. 2012 Nov; 38(11):1834–1842. [PubMed: 22806439]
15. Nordrehaug JE. Malignant arrhythmia in relation to serum potassium in acute myocardial infarction. The American journal of cardiology. 1985 Aug 30; 56(6):20d–23d.
16. Schoolwerth AC, Sica DA, Ballermann BJ, Wilcox CS. Renal Considerations in Angiotensin Converting Enzyme Inhibitor Therapy: A Statement for Healthcare Professionals From the Council on the Kidney in Cardiovascular Disease and the Council for High Blood Pressure Research of the American Heart Association. Circulation. 2001 Oct 16; 104(16):1985–1991. 2001. [PubMed: 11602506]
17. Moore ML, Bailey RR. Hyperkalaemia in patients in hospital. The New Zealand medical journal. 1989 Oct 25; 102(878):557–558. [PubMed: 2812582]
18. Lima MV, Ochiai ME, Cardoso JN, Morgado PC, Munhoz RT, Barretto AC. Hyperkalemia during spironolactone use in patients with decompensated heart failure. Arquivos brasileiros de cardiologia. 2008 Sep; 91(3):177–182. 194–179. [PubMed: 18853060]
19. Weir MR, Bakris GL, Bushinsky DA, et al. Patiromer in patients with kidney disease and hyperkalemia receiving RAAS inhibitors. The New England journal of medicine. 2015 Jan 15; 372(3):211–221. [PubMed: 25415805]
20. Kosiborod M, Rasmussen HS, Lavin P, et al. Effect of sodium zirconium cyclosilicate on potassium lowering for 28 days among outpatients with hyperkalemia: the HARMONIZE randomized clinical trial. Jama. 2014 Dec 3; 312(21):2223–2233. [PubMed: 25402495]
21. Packham DK, Rasmussen HS, Lavin PT, et al. Sodium zirconium cyclosilicate in hyperkalemia. The New England journal of medicine. 2015 Jan 15; 372(3):222–231. [PubMed: 25415807]

Statement of Clinical Significance

- We describe the high prevalence of hyperkalemia in patients presenting with acute myocardial infarction
- There is a steep increase in-hospital mortality associated with hyperkalemia in patients hospitalized with acute myocardial infarction who are and are not dependent on renal replacement therapy
- These findings are particularly topical in light of recently published data exploring outcomes associated with use of novel pharmacologic agents for the management of hyperkalemia

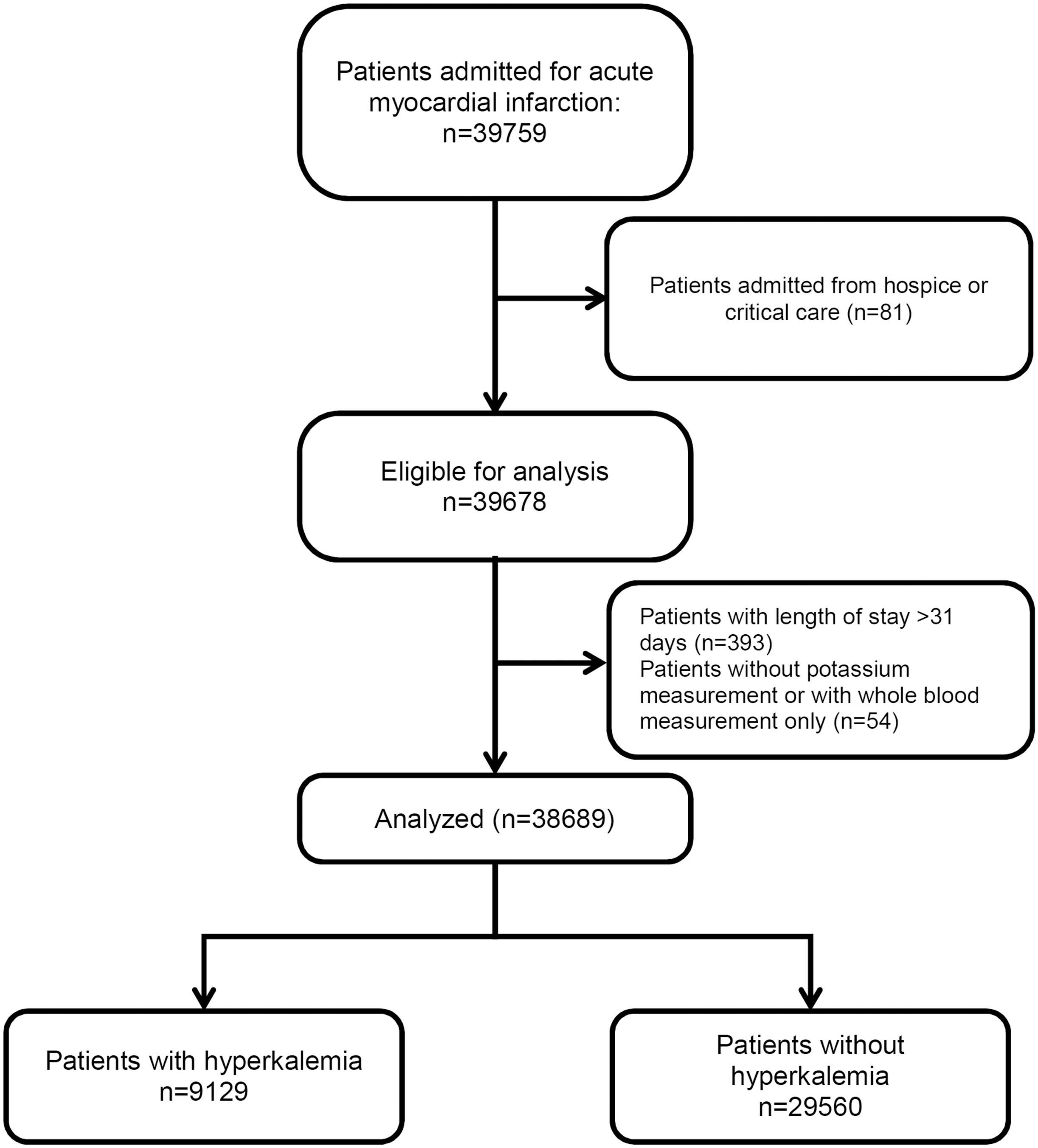

Figure 1. Flow chart of analytic cohort from Health Facts database

Flow chart of analytic cohort

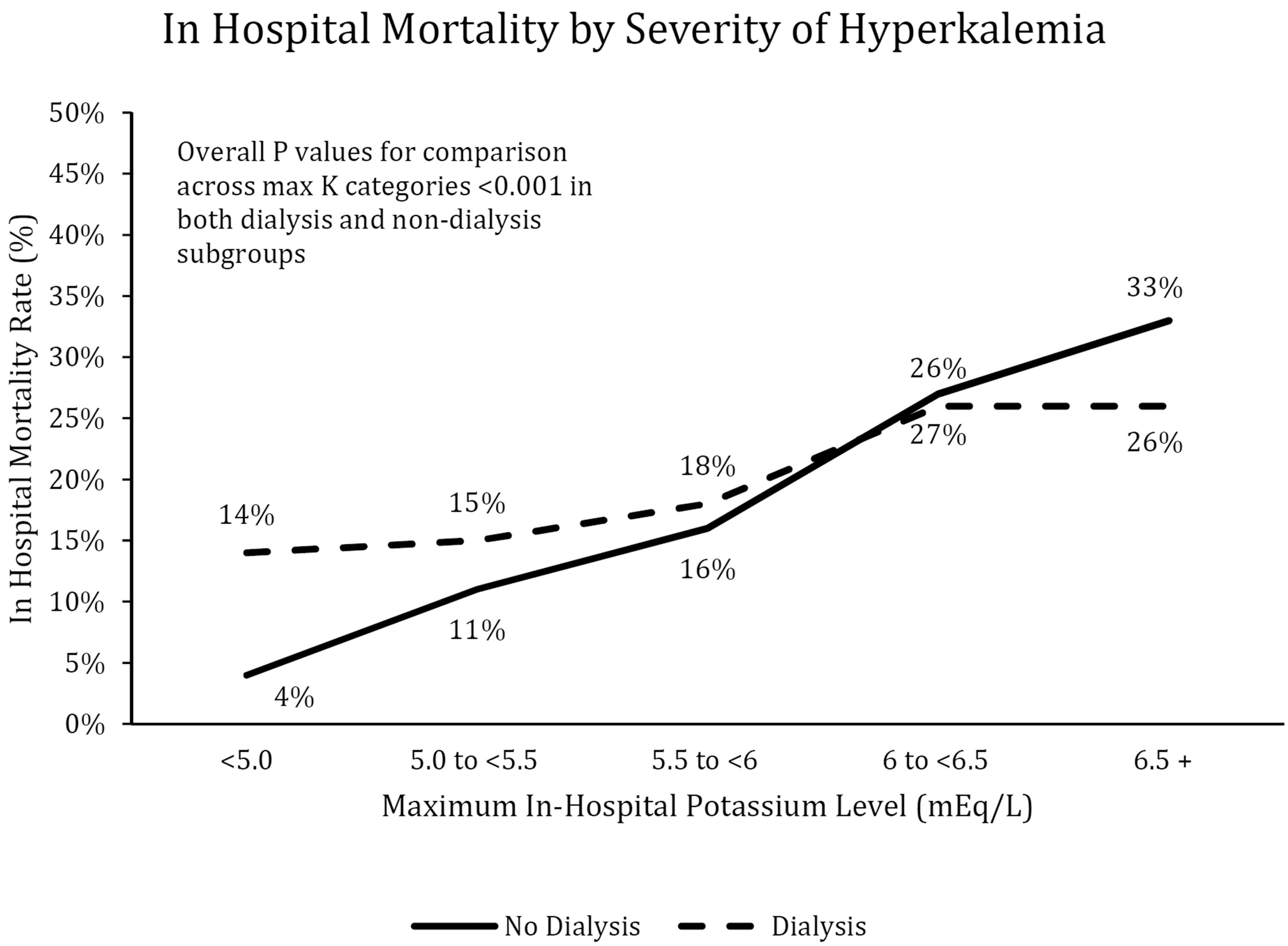

Figure 2. In-hospital mortality rates stratified by degree of hyperkalemia and dialysis status

In-hospital mortality in the Cerner Health Facts database stratified by categories of hyperkalemia severity and dialysis status

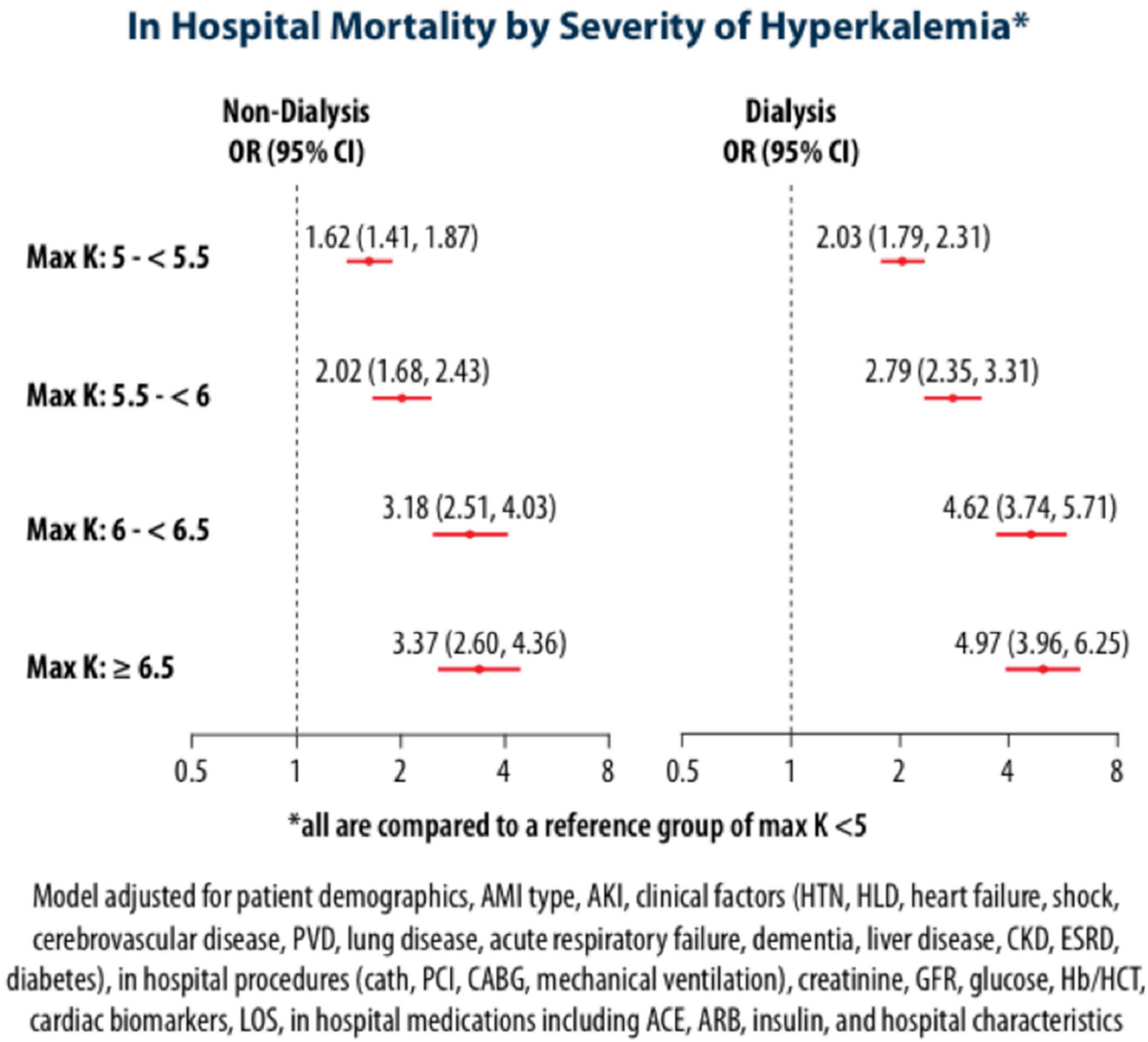

Figure 3. Adjusted in-hospital mortality based on severity of hyperkalemia

Adjusted and unadjusted odds of in-hospital mortality based on severity of hyperkalemia

Table 1

Baseline characteristics of overall patient cohort stratified by maximum potassium values (mEq/L)

Characteristics of patients in the overall cohort following acute myocardial infarction in the Health Facts database

	<5 n=29560	5 to <5.5 n = 5324	5.5 to <6 n=2082	6 to <6.5 n=930	>6.5 n=793	P–Value (trend)
Demographics						
Mean age, yrs	67.1±14.4	71.8±13.1	72.1±12.8	71.5±13.2	69.4±14.0	<0.001
Female	39.6%	43.4%	45.0%	44.7%	43.1%	<0.001
Caucasian	87.0%	86.1%	84.3%	82.0%	77.4%	<0.001
Comorbidities						
Current smoker	26.5%	15.0%	10.8%	10.8%	10.6%	<0.001
Hypertension	56.1%	51.0%	50.4%	50.9%	46.2%	<0.001
Dyslipidemia	44.8%	28.0%	20.5%	18.3%	16.0%	<0.001
Diabetes	23.9%	29.5%	31.5%	28.5%	25.3%	<0.001
Lung disease	12.1%	18.4%	19.5%	16.8%	16.5%	<0.001
STEMI	38.1%	33.5%	31.7%	32.2%%	37.2%	<0.001
Heart Failure	25.1%	45.5%	50.8%	49.2%	49.7%	<0.001
Acute kidney injury	16.1%	40.1%	50.1%	54.3%	55.0%	<0.001
Chronic kidney disease	7.2%	17.3%	27.0%	30.3%	32.7%	<0.001
Admission labs						
Admission Cr (mg/dL) (Median, IQR)	1.0 (0.9,1.3)	1.3(1.0,1.8)	1.5(1.1,2.3)	1.6(1.1,2.6)	1.7(1.1,3.2)	<0.001
Initial eGFR (mL/min/1.73sq.m) (Median, IQR)	68.8 (51.5,85.4)	52.2 (34.6,72.4)	42.0 (26.2,63.4)	39.2 (22.1,60.6)	35.9 (18.6,62.2)	<0.001
Mean glucose (mg/dL)	137.3±47.4	150.7±52.6	157.8±58.3	164.0±58.5	168.5±74.5	<0.001
Peak Troponin (ng/mL)	6.2 (1.6,25.1)	6.3 (1.6,25.4)	6.8 (1.7,27.7)	7.1 (1.7,26.8)	7.1 (1.5,31.7)	0.016
In-hospital medications						
ACE-I/ARB	62.5%	62.6%	59.3%	51.2%	50.7%	<0.001
IV Insulin	4.1%	11.1%	14.5%	14.4%	19.2%	<0.001
NSAIDs	5.9%	9.1%	9.2%	8.5%	7.2%	<0.001
Beta blockers	84.0%	84.1%	81.3%	76.5%	76.5%	<0.001
Diuretics	39.6%	66.8%	69.4%	67.4%	60.9%	<0.001
In-hospital procedures						

	<5 n=29560	5 to <5.5 n = 5324	5.5 to <6 n=2082	6 to <6.5 n=930	>6.5 n=793	P–Value (trend)
Coronary Angiogram	66.8%	56.0%	50.6%	47.7%	46.8%	<0.001
Percutaneous Coronary Intervention	45.7%	24.5%	20.8%	20.1%	21.8%	<0001
CABG	6.9%	21.3%	22.7%	21.7%	19.5%	<0.001
In-hospital complications						
Length of stay, hrs (Median, IQR)	91.1 (60.4,144.4)	168.5 (99.2,263.3)	192.2 (112.9,303.0)	176.8 (92.0,294.1)	171.5 (87.5,295.3)	<0.001
Shock	3.3%	7.8%	10.9%	14.0%	18.2%	<0.001
Mechanical ventilation	3.5%	8.2%	10.5%	13.9%	18.8%	<0.001
In-hospital mortality	4.2%	11.1%	16.6%	26.6%	31.7%	<0.001

STEMI: ST elevation myocardial infarction; NSAID: non steroidal anti-inflammatory drugs; Cr: creatinine; eGFR: estimated glomerular filtration rate; CABG: coronary artery bypass grafting

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Table 2

Unadjusted in hospital mortality rate by number of hyperkalemia values

In-hospital mortality based on number of hyperkalemia events

Number of Hyperkalemia Values	In-Hospital Mortality (%)	P-value for trend
0 values ≥5	4.2	<0.0001
1 value ≥5	13.4	
2 values of ≥5	16.2	
3 or more values ≥5	19.8	