Point-of-Care Potassium Measurement vs Artificial Intelligence–Enabled Electrocardiography for Hyperkalemia Detection

By Chin Lin, PhD, Chien-Chou Chen, MD, Chin-Sheng Lin, MD, PhD, Hung-Sheng Shang, MD, PhD, Chia-Cheng Lee, MD, Tom Chau, MD, PhD, and Shih-Hua Lin, MD

Background Hyperkalemia can be detected by point-of-care (POC) blood testing and by artificial intelligence–enabled electrocardiography (ECG). These 2 methods of detecting hyperkalemia have not been compared.
Objective To determine the accuracy of POC and ECG potassium measurements for hyperkalemia detection in patients with critical illness.
Methods This retrospective study involved intensive care patients in an academic medical center from October 2020 to September 2021. Patients who had 12-lead ECG, POC potassium measurement, and central laboratory potassium measurement within 1 hour were included. The POC potassium measurements were obtained from arterial blood gas analysis; ECG potassium measurements were calculated by a previously developed deep learning model. Hyperkalemia was defined as a central laboratory potassium measurement of 5.5 mEq/L or greater.
Results Fifteen patients with hyperkalemia and 252 patients without hyperkalemia were included. The POC and ECG potassium measurements were available about 35 minutes earlier than central laboratory results. Correlation with central laboratory potassium measurement was better for POC testing than for ECG (mean absolute errors of 0.211 mEq/L and 0.684 mEq/L, respectively). For POC potassium measurement, area under the receiver operating characteristic curve (AUC) to detect hyperkalemia was 0.933, sensitivity was 73.3%, and specificity was 98.4%. For ECG potassium measurement, AUC was 0.884, sensitivity was 93.3%, and specificity was 63.5%.
Conclusions The ECG potassium measurement, with its high sensitivity and coverage rate, may be used initially and followed by POC potassium measurement for rapid detection of life-threatening hyperkalemia. (*American Journal of Critical Care.* 2025;34:41-51)

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Hyperkalemia is a commonly encountered, life-threatening electrolyte emergency associated with high cardiovascular morbidity and mortality.[1] Hyperkalemia occurs in between 1% and 10% of hospitalized patients and is more prevalent in patients with advanced chronic kidney disease or acute kidney injury in the intensive care unit (ICU).[2,3] Incident hyperkalemia also is an independent predictor of mortality in patients with critical illness.[4]

Because hyperkalemia is potentially fatal due to its instigation of cardiac arrhythmias and sudden cardiac death, early recognition and prompt therapy are essential.[5] However, the standard diagnostic test for hyperkalemia is time-dependent central laboratory testing. Although point-of-care (POC) blood testing has been developed and applied to rapid detection of hyperkalemia in acutely ill patients, sampling error and dilution effects remain major concerns.[6] An alternative bloodless test for early detection of hyperkalemia in critically ill patients is warranted.

Artificial intelligence models can predict potassium level from the ECG much faster than one can get the results of central laboratory testing.

Because cardiac tissue is exquisitely sensitive to blood potassium level for its physiologic function, changes to the heart's electrical activity caused by hyperkalemia can be detected by electrocardiography (ECG) used as a noninvasive bedside tool. The classic sequence of ECG changes associated with increasingly severe hyperkalemia include tall, peaked T waves; a shortened QT interval, lengthened PR interval, and loss of the P wave; a widening QRS complex; and ultimately a sine wave morphology.[7-10] However, these typical ECG abnormalities are identified in only 14% to 50% of patients with hyperkalemia, even by experienced clinicians.[11] Therefore, high-quality studies of the ECG properties of hyperkalemia are still warranted.[12] With large annotated ECG data sets, artificial intelligence techniques based on deep learning models have achieved human-level performance.[13-19] Currently, artificial intelligence models have been validated to quickly detect and quantify various degrees of hyperkalemia.[20-22] However, a comparison of the accuracy and clinical utility of 2 modalities used for rapid hyperkalemia assessment, POC potassium measurement and ECG potassium measurement, has not been conducted. The aim of this study was to determine the accuracy of POC and ECG potassium measurements for central laboratory–validated hyperkalemia detection in patients with critical illness.

About the Authors

Chin Lin is an associate professor, School of Medicine, National Defense Medical Center, Taipei, Taiwan, Republic of China. **Chien-Chou Chen** is a resident physician, Division of Nephrology, Department of Medicine, Tri-Service General Hospital, National Defense Medical Center, Taipei. **Chin-Sheng Lin** is a professor, Division of Cardiology, Department of Internal Medicine, Tri-Service General Hospital, National Defense Medical Center, Taipei. **Hung-Sheng Shang** is an associate professor, Division of Clinical Pathology, Department of Pathology, Tri-Service General Hospital, National Defense Medical Center, Taipei. **Chia-Cheng Lee** is an assistant professor, Department of Medical Informatics, and visiting staff, Division of Colorectal Surgery, Department of Surgery, Tri-Service General Hospital, National Defense Medical Center, Taipei. **Tom Chau** is a medical director, Department of Medicine, Providence St Vincent Medical Center, Portland, Oregon. **Shih-Hua Lin** is a professor, Division of Nephrology, Department of Medicine, Tri-Service General Hospital, National Defense Medical Center, Taipei.

Corresponding author: Dr Shih-Hua Lin, Division of Nephrology, Department of Medicine, Tri-Service General Hospital, National Defense Medical Center, Taipei, Taiwan (email: l521116@ndmctsgh.edu.tw).

Methods

Ethics Approval and Consent to Participate

This study was approved by Tri-Service General Hospital's institutional review board (C202105049). Patient consent was waived because data were collected retrospectively and in anonymized files and encrypted from the hospital to the data controller.

Data Source and Population

This retrospective cohort study involved ICU patients in a single academic medical center with 1800 beds, including 160 beds in various ICUs, between October 2020 and September 2021. We included patients from the cardiovascular ICU, cardiovascular surgical ICU, medical ICU, and surgical ICU. Included patients received POC arterial blood gas analysis (including potassium measurement), 12-lead ECG, and central laboratory potassium measurement all within 1 hour. We included only 1 record for each patient to avoid dependency issues. For patients with more than 1 record, we selected

the record with the smallest difference in examination time. Patients' characteristics and comorbid conditions were collected from the electronic medical record. Laboratory data with the closest time stamp were assigned to each ECG record. The study had no additional exclusion criteria.

Measurements of Potassium

Central laboratory potassium measurements were performed with a chemistry analyzer (AU5800, Beckman Coulter) using plasma obtained from whole blood. Hyperkalemia was defined as a potassium level of greater than or equal to 5.5 mEq/L (to convert to mmol/L, multiply by 1) as measured in the central laboratory. Pseudohyperkalemia was excluded on laboratory analysis on the basis of evidence of hemolysis and plasma potassium interference indexes, the standard method for testing potassium abnormalities in a clinical setting.

Point-of-care potassium measurements were performed with an arterial blood gas analyzer (pHOx Ultra, Nova Biomedical) using whole blood. Assay quality was automatically assessed by the equipment and by trained laboratory technicians. This POC device is designed to swiftly confirm a clinical hypothesis that a patient's signs are caused by an abnormal potassium level. The reported sensitivity and specificity of this device are 66.4% and 98.9%, respectively.[23]

Electrocardiography potassium measurements ranged from 1.5 to 7.5 mEq/L, as estimated by a deep learning model trained on a database comprising 66 321 ECGs with corresponding central laboratory potassium measurements obtained within 1 hour.[22] Subsequent validation revealed an expected sensitivity and specificity of approximately 87.5% and 88.9%, respectively.[24] In this study, each ECG was automatically processed by this deep learning model to provide an estimated potassium measurement.

Study Covariates

Study covariates, including demographics, medical comorbidities, and laboratory test results, were obtained from the electronic medical record. We used *International Classification of Diseases, Ninth Revision*, and *International Classification of Diseases, Tenth Revision*, to define diabetes mellitus, hypertension, hyperlipidemia, chronic kidney disease, coronary artery disease, stroke, heart failure, and chronic obstructive pulmonary disease, as previously reported.[19] In addition to central laboratory potassium measurement, we obtained ICU laboratory data including complete blood count, blood pH, and levels of bicarbonate, electrolytes, glucose, alanine aminotransferase, albumin, C-reactive protein, N-terminal pro–brain type natriuretic peptide, D-dimer, troponin I, and kidney function values.

Statistical Power Estimation

The statistical power estimation was based on presumed sensitivities of 66.4% for POC potassium measurement[23] and 87.5% for ECG potassium measurement[24] and presumed specificities of 98.9% for POC potassium measurement[23] and 88.9% for ECG potassium measurement.[24] Given the known numbers of cases (15 patients with hyperkalemia) and controls (252 patients without hyperkalemia) and an acceptable margin of error of 5%, the estimated power for validating the sensitivity of POC and ECG potassium measurement was 31.8% and 44.2%, respectively; the estimated power for validating the specificity of POC and ECG potassium measurement was greater than 99.9% and 98.8%, respectively.

Statistical Analysis

The baseline characteristics of patients with and without hyperkalemia were calculated as means and SDs or percentages as appropriate. Because of the skewed distribution of laboratory results, these data were calculated as medians and IQRs. We used *t* tests, Wilcoxon rank sum tests, and χ^2 tests to test differences in means, medians, and percentages, respectively. Statistical analyses were performed with R, version 3.4.4 (R Foundation for Statistical Computing). We used a significance level of P less than .05 for all analyses.

The primary aim of this study was to compare the accuracy of POC and ECG potassium measurements for diagnosing hyperkalemia. These data were shown in scatter plots and their relationships were quantified with the Pearson correlation coefficient (r) and mean absolute error. We also examined mean absolute errors stratified by central laboratory potassium measurement. Bland-Altman plots were constructed to show mean differences and 95% CIs. Receiver operating characteristic curve analyses included calculation of area under the curve (AUC), sensitivity, specificity, positive predictive value, and negative predictive value for detecting hyperkalemia (defined as a central laboratory potassium measurement of ≥5.5 mEq/L). Because some confounders can affect the accuracy of POC and ECG potassium measurements, further subgroup analyses also were conducted.

Results

Patient Characteristics

Two hundred sixty-seven patients admitted to an ICU met the inclusion criteria. Patient distribution among ICUs was 52 (19.5%) in the cardiovascular

ICU, 98 (36.7%) in the cardiovascular surgical ICU, 89 (33.3%) in the medical ICU, and 28 (10.5%) in the surgical ICU. Fifteen patients had hyperkalemia according to central laboratory potassium measurement (potassium level ≥ 5.5 mEq/L) and 252 patients did not have hyperkalemia. Patient characteristics are shown in Table 1. Compared with patients without hyperkalemia, patients with hyperkalemia had a higher prevalence of chronic kidney disease (53% vs 25.8%) and chronic obstructive pulmonary disease (40% vs 13.9%). Patients with hyperkalemia also exhibited significantly worse renal function (median serum creatinine level, 2.6 mg/dL vs 1.2 mg/dL), a higher degree of azotemia (median serum urea nitrogen level, 52.5 mg/dL vs 26.0 mg/dL), a lower albumin level (median, 2.9 g/dL vs 3.3 g/dL), and a higher serum N-terminal pro–brain type natriuretic peptide level (median, 33 130.0 pg/mL vs 2682.0 pg/mL). Other characteristics were not significantly different between the groups.

Diagnostic Accuracy of POC and ECG Potassium Measurements

Although the POC, ECG, and central laboratory potassium measurements were obtained at similar times for patients in this study, both POC and ECG potassium measurements were available for interpretation approximately 35 minutes earlier than the formal report of central laboratory potassium measurement. Table 2 summarizes the performance of POC and ECG potassium measurements for estimating central laboratory–validated hyperkalemia. Figure 1 shows scatter plots and Bland-Altman plots evaluating the accuracy of POC and ECG potassium measurements. Correlation with central laboratory potassium measurement was lower for ECG potassium measurement ($r = 0.492$) than for POC potassium measurement ($r = 0.867$). The mean difference between central laboratory and POC potassium measurements (0.05 mEq/L) was smaller than the mean difference between central laboratory and ECG potassium measurements (0.40 mEq/L). The overall mean absolute error was also lower for POC potassium measurement (0.211 mEq/L) than for ECG potassium measurement (0.684 mEq/L). However, the mean absolute errors for ECG potassium measurement were largely consistent across the spectrum of central laboratory potassium measurements (mean absolute error, 0.676 for central laboratory values < 5.5 mEq/L and 0.821 for central laboratory values ≥ 5.5 mEq/L; $P = .34$), whereas the mean absolute error for POC potassium measurement was higher for central laboratory potassium measurements indicating hyperkalemia (mean absolute error, 0.193 for central laboratory values < 5.5 mEq/L and 0.515 for central laboratory values ≥ 5.5 mEq/L; $P = .004$).

> Artificial intelligence–enabled hyperkalemia detection not only provides more immediate results, but also has prognostic value.

To evaluate the AUC, sensitivity, and specificity of POC and ECG potassium measurements for hyperkalemia detection, we categorized patients as having or not having hyperkalemia according to a central laboratory potassium measurement of 5.5 mEq/L or greater. The POC potassium measurement had an AUC of 0.933, a sensitivity of 73.3%, a specificity of 98.4%, a positive predictive value of 73.3%, and a negative predictive value of 98.4% for detecting hyperkalemia (Figure 2, Table 1). Compared with POC potassium measurement, ECG potassium measurement had a similar AUC (0.884) ($P = .36$), a higher sensitivity (93.3%), a lower specificity (63.5%), a lower positive predictive value (13.2%), and a higher negative predictive value (99.4%).

Confounders Affecting Accuracy of POC and ECG Potassium Measurements

Because some confounders may affect the accuracy of POC and ECG potassium measurements, we performed further subgroup analyses (Figure 3). Point-of-care potassium measurement performed very well in these subgroups; AUCs were 0.987 for patients without septic shock, 1.000 for patients without mechanical ventilation, 0.996 for patients with renal replacement therapy, 0.998 for patients without inotropic or vasopressor support, and 0.998 for patients in the surgical ICU. These results indicate that POC potassium measurement was most accurate in patients with stable or less medically complex disease. Point-of-care potassium measurement was less accurate for patients with more critical conditions, especially septic shock (AUC = 0.845). In contrast, the performance of ECG potassium measurement was relatively stable across the subgroups. For ECG potassium measurement, the lowest AUC (0.869) was for patients with mechanical ventilation, and the highest AUC (0.943) was for patients admitted to surgical ICUs and patients without mechanical ventilation.

Discussion

To our knowledge, this study is the first to compare the accuracy of POC and ECG potassium measurements

Table 1
Characteristics of patients with and without central laboratory–validated hyperkalemia[a]

Characteristic	No. (%) of patients[b]		P
	Hyperkalemia (n = 15)	No hyperkalemia (n = 252)	
Potassium test			
Point-of-care test			<.001
No hyperkalemia	4 (27)	248 (98.4)	
Hyperkalemia	11 (73)	4 (1.6)	
Electrocardiography test			<.001
No hyperkalemia	1 (7)	160 (63.5)	
Hyperkalemia	14 (93)	92 (36.5)	
Type of intensive care unit			.02
Medical	10 (67)	79 (31.3)	
Cardiovascular	1 (7)	51 (20.2)	
Surgical	2 (13)	26 (10.3)	
Cardiovascular surgical	2 (13)	96 (38.1)	
Demographics			
Male sex	10 (67)	167 (66.3)	.98
Age, mean (SD), y	69.4 (18.4)	69.1 (15.5)	.85
Disease history			
Diabetes mellitus	6 (40)	92 (36.5)	.79
Hypertension	8 (53)	129 (51.2)	.87
Chronic kidney disease	8 (53)	65 (25.8)	.03
Acute myocardial infraction	1 (7)	28 (11.1)	>.99
Stroke	3 (20)	42 (16.7)	.72
Coronary artery disease	5 (33)	115 (45.6)	.35
Heart failure	3 (20)	72 (28.6)	.57
Chronic obstructive pulmonary disease	6 (40)	35 (13.9)	.02
Disease severity			
APACHE II score, mean (SD)	24.8 (9.4)	21.0 (8.9)	.10
Septic shock	6 (40)	65 (25.8)	.24
Mechanical ventilation	12 (80)	199 (79.0)	>.99
Renal replacement therapy	5 (33)	45 (17.9)	.17
Inotropic or vasopressor support	11 (73)	148 (58.7)	.26
Laboratory data,[c] median (IQR)			
Hemoglobin, g/dL	8.8 (7.0-9.7)	9.4 (8.2-10.7)	.11
Platelet count, x10^3/μL	118.0 (81.5-149.0)	136.0 (90.0-190.8)	.32
Blood pH	7.4 (7.2-7.4)	7.4 (7.3-7.5)	.99
Sodium, mEq/L	135.0 (134.0-143.0)	140.0 (137.0-143.0)	.19
Chloride, mEq/L	102.5 (97.0-106.0)	105.0 (101.0-110.0)	.10
Bicarbonate, mEq/L	31.4 (25.9-32.2)	20.5 (18.1-26.2)	.14
Total calcium, mg/dL	8.7 (8.5-8.8)	8.3 (7.8-8.8)	.41
Glucose, mg/dL	171.5 (110.2-244.0)	180.0 (129.0-259.5)	.55
Alanine aminotransferase, U/L	28.5 (17.0-62.5)	18.0 (13.0-32.2)	.12
Albumin, g/dL	2.9 (2.0-3.3)	3.3 (2.9-3.7)	.02
C-reactive protein, mg/dL	2.8 (1.5-12.6)	5.1 (2.0-9.8)	.76
N-terminal pro–brain type natriuretic peptide, pg/mL	33130.0 (4340.0-35000.0)	2682.0 (506.5-14280.5)	.02
D-Dimer, ng/mL	7860.0 (1800.0-20000.0)	3795.0 (1467.5-9155.0)	.23
Troponin I, ng/L	1490.0 (76.5-3031.0)	1110.0 (60.8-6996.8)	.40
Creatinine, mg/dL	2.6 (2.0-4.4)	1.2 (0.8-2.0)	.005
Serum urea nitrogen, mg/dL	52.5 (37.8-73.8)	26.0 (17.0-44.5)	.005

Abbreviation: APACHE II, Acute Physiology and Chronic Health Evaluation II.
SI conversion factor: To convert sodium, chloride, bicarbonate, and potassium to mmol/L, multiply by 1.

[a] Hyperkalemia defined as central laboratory potassium measurement of 5.5 mEq/L or greater.
[b] Unless otherwise indicated in first column.
[c] Reference ranges for laboratory values: hemoglobin, 13-18 g/dL in men and 11-16 g/dL in women; platelet count, 150-400 x10^3/μL; sodium, 135-145 mEq/L; chloride, 102-112 mEq/L; bicarbonate, 24-40 mEq/L; total calcium, 8.8-10.2 mg/dL; glucose, 70-140 mg/dL; alanine aminotransferase, <40 U/L; albumin, 3.5-5.5 g/dL; C-reactive protein, <1 mg/dL; N-terminal pro–brain type natriuretic peptide, <125 pg/mL; D-dimer, <500 ng/mL; troponin I, <500 ng/L; creatinine, <1.4 mg/dL in men and <1.3 mg/dL in women; serum urea nitrogen, 7-20 mg/dL.

Table 2
Performance of point-of-care and electrocardiography potassium measurements for estimating central laboratory–validated hyperkalemia

Variable	Point-of-care test	Electrocardiography test
Mean absolute error, mEq/L		
All	0.211	0.684
No hyperkalemia	0.193	0.676
Hyperkalemia	0.515	0.821
Pearson correlation (*r*)		
All	0.867	0.492
Difference distribution, mean (SD), mEq/L		
All	0.05 (0.41)	0.40 (0.82)
AUROC for detecting central laboratory–validated hyperkalemia		
All	0.933	0.884
Patients without septic shock	0.987	0.881
Patients with septic shock	0.845	0.890
Patients without mechanical ventilation	1.000	0.943
Patients with mechanical ventilation	0.916	0.869
Patients without renal replacement therapy	0.904	0.881
Patients with renal replacement therapy	0.996	0.880
Patients without intropic or vasopressor support	0.998	0.892
Patients with intropic or vasopressor support	0.908	0.881
Patients in nonsurgical intensive care unit	0.907	0.879
Patients in surgical intensive care unit	0.998	0.943
Sensitivity for detecting central laboratory–validated hyperkalemia		
All	0.733	0.933
Specificity for detecting central laboratory–validated hyperkalemia		
All	0.984	0.635

Abbreviation: AUROC, area under receiver operating characteristic curve.

for hyperkalemia detection against a reference standard in critically ill adult patients. Both POC and ECG potassium measurements were available much sooner at the bedside than was the central laboratory result. Point-of-care potassium measurement correlated better with central laboratory potassium measurement and had a significantly lower mean absolute error than did ECG potassium measurement. The AUCs of POC and ECG potassium measurements were not significantly different.

Reasons to develop POC tests using whole blood to rapidly detect laboratory abnormalities include equipment accessibility outside the central laboratory,[25,26] difficulty obtaining blood samples (eg, pediatric patients and interhospital transport), and critical situations with a short time window to change patient treatment (eg, in the emergency department and ICU).[27-29] However, clinicians' low confidence in the results has prevented the use of these instruments to their full potential.[30] A previous study in patients with chronic kidney disease demonstrated a mean difference between POC and central laboratory potassium measurements of −0.4 mEq/L (95% CI, −1.4 to 0.6 mEq/L) and an AUC of 0.827.[23] In our study of critically ill patients in the ICU, the mean difference between POC and central laboratory potassium measurements was 0.05 mEq/L and the AUC was 0.933. The lack of precision was principally driven by low sensitivity in the previous study (66.4%) and in our study (73.3%). Adding 0.4 mEq/L to the POC potassium measurement has been suggested to increase its AUC to 0.8967 and sensitivity to 85.5%.[23]

Our study also showed that POC potassium measurement was affected by septic shock, inotropic or vasopressor support, and renal replacement therapy. In these cases, the errors of POC potassium measurement may have been caused by operational factors such as the collection of variable volumes of arterial blood or heparin in syringes.[25,27] The fact that the mean absolute error of POC potassium measurement was higher for patients with hyperkalemia (0.515) than for patients without hyperkalemia (0.193) may support this notion. The more complex the patient's condition, the more opportunities for operational errors to occur.[31-33] Accordingly, POC potassium measurement has been suggested as a complementary test but not as a replacement for central laboratory potassium measurement.[34]

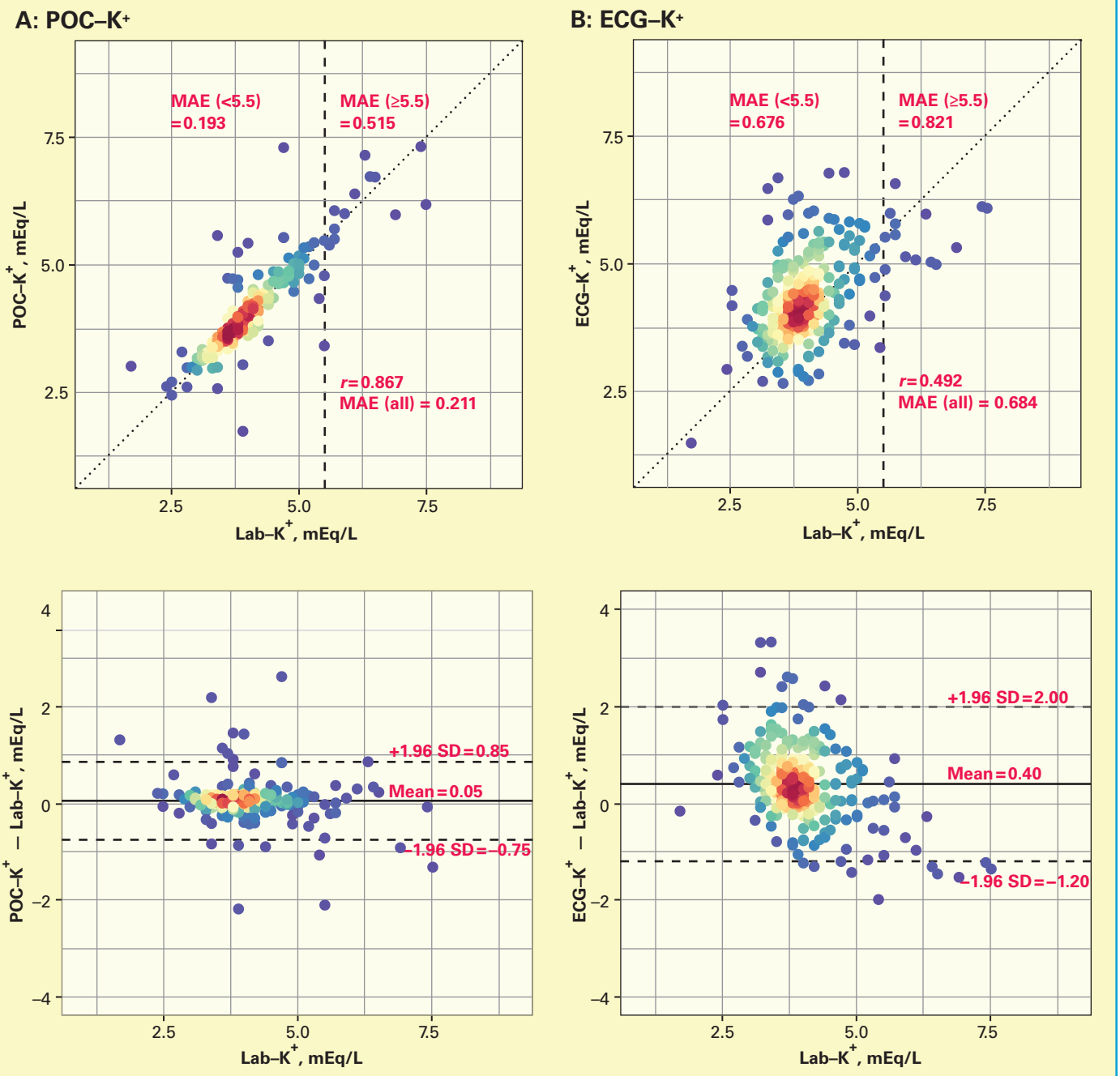

Figure 1 Scatter plots and Bland-Altman plots of potassium measurements. A, Point-of-care potassium measurement (POC-K⁺). B, Electrocardiography potassium measurement (ECG-K⁺). Each x-axis indicates central laboratory potassium measurement (Lab-K⁺). Each y-axis indicates the POC-K⁺ or ECG-K⁺. Red points represent the highest density, followed by yellow, green, light blue, and dark blue. The Pearson correlation coefficient (*r*) and mean absolute errors (MAEs) are shown for each modality. The dotted line is the consistent line and the dashed line denotes the cutoff for hyperkalemia (Lab-K⁺ ≥ 5.5 mEq/L). The stratified MAEs are also presented. The *P* values from a 2-sided permutation test (n = 1000) for the MAE comparing POC-K⁺ and ECG-K⁺ were .004 and .34, respectively.

In contrast to blood-based (POC and central laboratory) potassium measurements, which have a propensity for dilution effects and pseudohyperkalemia caused by hemolysis, leukocytosis, and thrombocytosis, ECG potassium measurement detects the effects of hyperkalemia on cardiac electrical activity (also called cardiac hyperkalemia) and helps exclude pseudohyperkalemia. Point-of-care machines that measure potassium level are unable to detect hemolysis. Although we excluded patients with

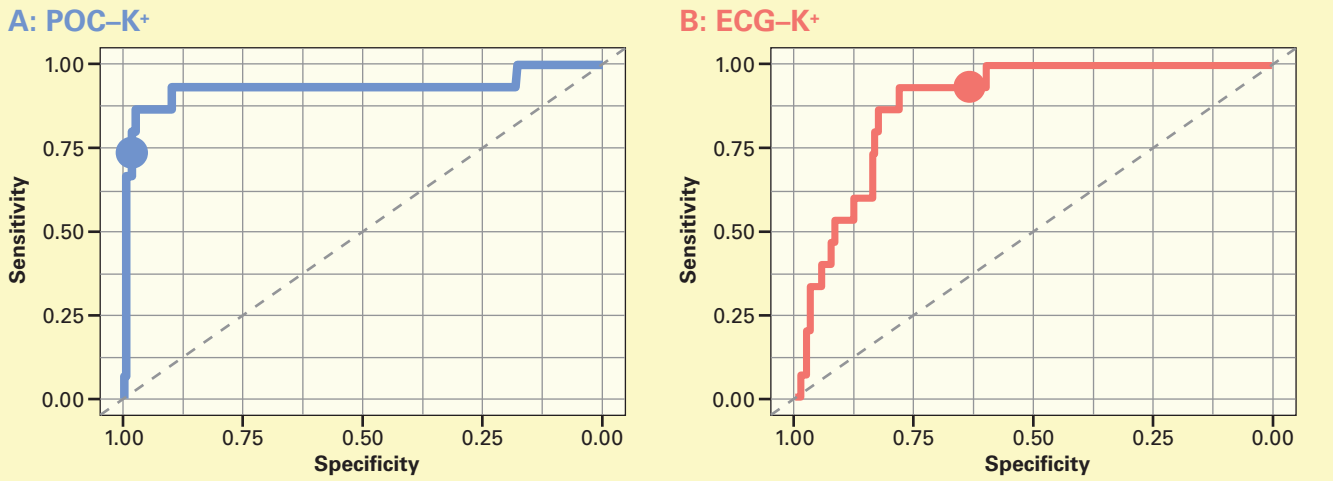

Figure 2 Receiver operating characteristic (ROC) curve analysis for accuracy of potassium measurements. A, Point-of-care potassium measurement (POC-K+). The cutoff point is 5.5 mEq/L. B, Electrocardiography potassium measurement (ECG-K+). The cutoff point for ECG-K+ was based on the maximum Youden index (sensitivity + specificity − 1) reported in earlier studies.[23,24]

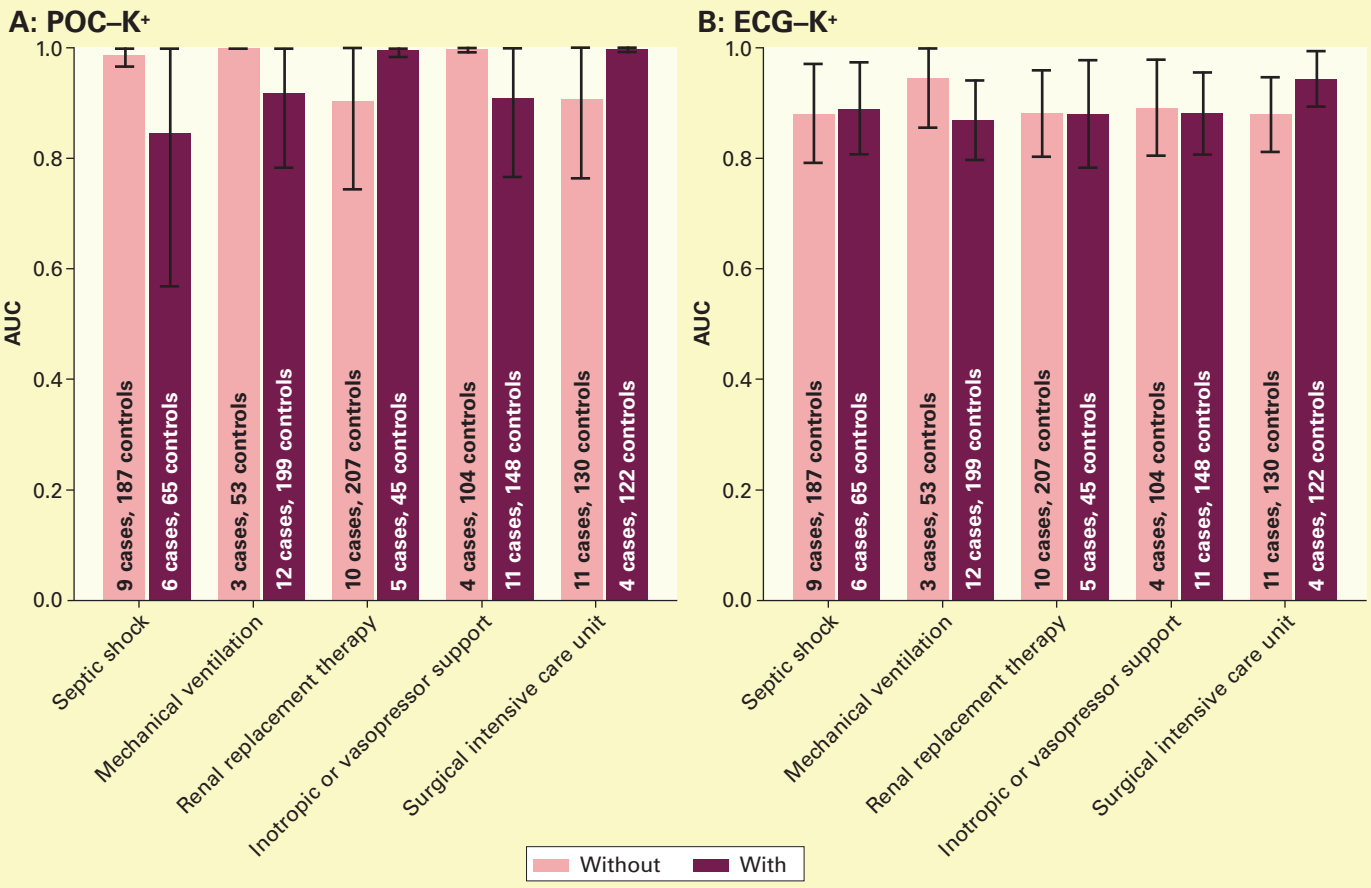

Figure 3 Stratified receiver operating characteristic (ROC) curve analysis for accuracy of potassium measurements. Point-of-care potassium measurement (POC-K+). B, Electrocardiography potassium measurement (ECG-K+). Central laboratory potassium measurement was the reference standard. The analyses are stratified by conditions listed on the x-axis. The bars represent patients with and without each condition. The y-axis shows the area under the ROC curve (AUC), and the error bars represent 95% CIs. Text within the bars indicates the number of cases (patients with central laboratory potassium levels ≥ 5.5 mEq/L) and controls (patients with central laboratory potassium levels < 5.5 mEq/L).

hemolysis and other potential causes of pseudohyperkalemia to allow for clear comparisons between the 3 modalities, thus diminishing this advantage of ECG potassium measurement, the AUC of ECG potassium measurement (0.884) was not inferior to that of POC potassium measurement (0.933) ($P = .36$).

Because the sensitivity and specificity of POC and ECG potassium measurements differ, the scenarios for which each is suitable differ. In our study, the sensitivity for detecting hyperkalemia was higher for ECG potassium measurement (93.3%) than for POC potassium measurement, consistent with other recently published studies that included sensitivity analyses.[20-22] The negative predictive value for hyperkalemia was also higher for ECG potassium measurement (99.4%). With its higher sensitivity and negative predictive value, ECG potassium measurement may be used as a first-line screening tool for hyperkalemia in high-risk patients with critical illness. Guidelines for managing hyperkalemia recommend checking for ECG changes as a top priority because of the clinical significance of cardiac hyperkalemia.[35] Because ECG monitoring is needed for a wide range of patient conditions, especially in the ICU, ECG potassium measurement can be obtained from routine ECG examinations without many additional steps. An artificial intelligence–enabled ECG system may flag potentially overlooked patients with hyperkalemia and notify physicians to shorten the time to treatment. A prospective trial should be conducted to explore the clinical benefit of an artificial intelligence–enabled ECG system.

Electrocardiography potassium measurement, with its relatively low specificity for hyperkalemia detection in our study (63.5%, similar to specificities of 60.3% to 70.0% in previous studies),[31] has a relatively high rate of false-positive results and a low positive predictive value, which may be a concern. The low positive predictive value of ECG potassium measurement was due to its low specificity compared with POC potassium measurement (98.4%) and the low prevalence of hyperkalemia in patients in our study (5.6%). Therefore, use of ECG potassium measurement may be more suitable in a patient population with a higher hyperkalemia prevalence, such as patients with septic shock (26.6% in this study) or those whose physicians suspect hyperkalemia. In the subgroup of patients with septic shock in this study, ECG potassium measurement (AUC = 0.890) performed better than POC potassium measurement (AUC = 0.845). Another study we recently published highlighted the fact that patients with false-positive hyperkalemia findings on ECG potassium measurement had worse clinical parameters and adverse outcomes, including mortality, than patients with true-positive hyperkalemia findings.[24]

Early detection of hyperkalemia with POC and ECG potassium measurements has the potential to greatly affect patient outcomes. In a retrospective analysis of 932 hospitalized adults, patients with severe hyperkalemia had high rates of arrhythmia (35.2%) and cardiac arrest (43.3%).[36] Furthermore, a failure to lower serum potassium level by more than 1.0 mEq/L immediately after identification of severe hyperkalemia was predictive of death,[4] and total duration of hyperkalemia was also associated with death.[37] Electrocardiography is widely used for various indications, with approximately 3 million ECGs conducted worldwide daily.[38] Recently, the concept of opportunistic screening, inspired by radiology, has gained popularity.[39] This approach involves identifying incidental findings on radiologic imaging conducted for unrelated reasons, leading to better prognoses through early intervention. We consider ECG potassium measurement to be well suited for opportunistic screening for hyperkalemia. In contrast, POC potassium measurement is typically a hypothesis-driven tool that physicians use for rapid confirmation when potential signs of hyperkalemia are detected, and an abnormal ECG potassium measurement could serve as a sign of hyperkalemia. Because of the complementary advantages of POC potassium measurement for specificity and ECG potassium measurement for sensitivity and coverage, we suggest either screening patients with ECG potassium measurement followed by POC potassium measurement or testing patients with both modalities at the same time.

This study has some limitations. First, data came from a single medical center and lacked external validation from other medical institutions. Second, for the sake of data cleanliness, we included only patients in the ICU who had POC, ECG, and central laboratory potassium measurements all within 1 hour, which might have led to selection bias and decreased the generalizability of the results. Third, because the POC, ECG, and central laboratory potassium measurements did not necessarily occur at the beginning of the ICU admission, confounders such as medications and dialysis treatment may have influenced the results. Fourth, our study was retrospective; prospective studies are warranted to validate our findings regarding POC and ECG potassium measurements.

Conclusion

Hyperkalemia, a silent cause of potentially fatal cardiac arrhythmias, requires early recognition to

initiate rapid management. To our knowledge, this study is the first to compare 2 POC tools for hyperkalemia detection. We found that POC potassium measurement and bloodless ECG potassium measurement provided complementary advantages for specificity and sensitivity, respectively. Our findings suggest that ECG potassium measurement can leverage the widespread use of ECG as an opportunistic screening tool for hyperkalemia. Once an abnormality is detected with ECG potassium measurement, POC potassium measurement can be used for immediate verification, reducing the waiting time for central laboratory results. Further studies of POC and ECG potassium measurements are warranted to validate their accuracy in other critical care settings such as emergency departments.

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CE 1.0 Hour Category A

Notice to CE enrollees:

This article has been designated for CE contact hour(s). Increasing knowledge on the following objectives is the desired outcome of this activity:

1. Describe the error range of point-of-care devices and artificial intelligence–enabled electrocardiography on potassium tests.
2. Compare the accuracy between point-of-care devices and artificial intelligence–enabled electrocardiography for hyperkalemia detection.
3. Demonstrate the different advantages between point-of-care devices and artificial intelligence–enabled electrocardiography.

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