Evaluation of Harmonization Across Siemens Healthineers Blood Gas Systems and the Atellica CH 930 Clinical Chemistry System for Common Measurands

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Introduction

Assessment and laboratory examinations are the primary method used by clinicians to evaluate a patient's condition and provide a diagnosis. The ability to perform laboratory tests quickly and receive accurate results allows for a more effective diagnosis, prognosis, and treatment plan. The development of point-of-care testing (POCT) has revolutionized the way in which patient biodata are sampled, analyzed, and reported. Convenient and easy-to-use POCT devices have combined portability with the accuracy of traditional laboratory analysis and instrumentation.[1] The turnaround time (TAT) from sample collection to test result has improved with POCT versus central laboratory testing, which allows for a quicker diagnosis and initiation of therapy.[2] TAT has been the primary driving force behind the implementation of POCT devices.[3] However, it is imperative that the POCT devices provide accurate results with minimal variability between portable and stationary devices, including those in the central laboratory. There are many types of POCT devices currently in existence and use, including blood gas analyzers, to name one category.

In the arena of blood gas analyzers, Siemens Healthineers offers the following platforms: the epoc® Blood Analysis System (for patient-side testing), RAPIDPoint® 500e Blood Gas System (designed for POC), RAPIDLab® 1265 Blood Gas System (clinical laboratory system), and RAPIDLab® 348EX Blood Gas System (designed for lower-volume testing sites). Siemens Healthineers recently introduced the Atellica® Chemistry (CH) 930 Analyzer, a high-throughput clinical chemistry system based in the central laboratory. The need for correlation and harmonization among these devices (e.g., POCT and central laboratory testing) at clinically relevant decision points is of utmost importance, specifically as a patient transitions between levels of care. Healthcare providers expect consistent results for the same patient sample when analyzed across various platforms and with different measurement procedures. A previously performed study to determine correlation between Siemens Healthineers platforms and a clinical chemistry system found comparable results for the same patient sample.[4] Harmonization at medical decision levels (MDLs) was demonstrated between the platforms studied. Consistent and comparable results across platforms leave no room for misinterpretation and translate into confident diagnoses and appropriate treatments.

To further investigate harmonization across its most current clinical platforms, Siemens Healthineers conducted an internal study designed to assess the variability in results between the epoc, RAPIDPoint 500e, RAPIDLab 1265, RAPIDLab 348EX, and the Atellica CH 930 systems.

Instrument Overview

A brief description of the blood gas systems and clinical chemistry system that were included in this study is provided below. It is important to understand the differences between these systems and what they offer to the diagnostic assessment, particularly when these instruments are being directly compared with one another.

RAPIDPoint 500e Blood Gas System

Siemens Healthineers RAPIDPoint 500e system (Figure 1) is a point-of-care analyzer that measures pH, blood gases, electrolytes, glucose, lactate, and full CO-oximetry, providing patient results in just 60 seconds on a single sample of heparinized whole blood. The easy-to-use, cartridge-based technology offers heightened operational simplicity while leveraging Siemens Healthineers proprietary Integri-sense™ Technology to enable robust accuracy from sample to sample and confidence in every result.

The measurement cartridge resides on the system for up to 28 days, and the variety of cartridge test sizes available accommodates low- to high-volume test sites, making the RAPIDPoint 500e system ideal for both point-of-care and laboratory settings. The sensors used in the RAPIDPoint 500e system are miniaturized and planar chip in design and represent an integral component of the RAPIDPoint measurement cartridge. The principal methodologies of the system include amperometry, potentiometry, and spectrophotometry.

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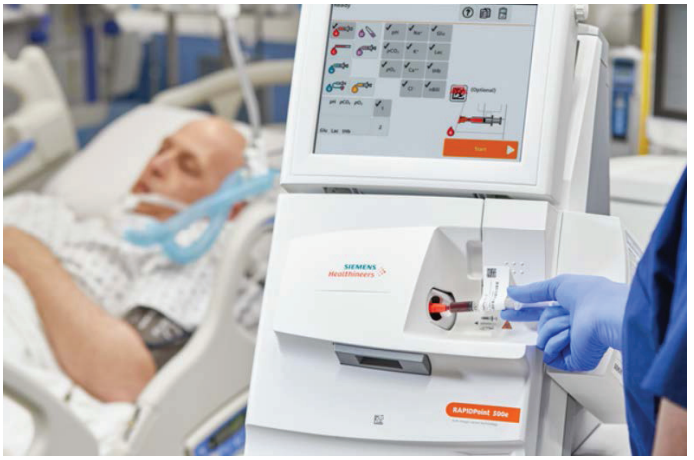

Figure 1. RAPIDPoint 500e Blood Gas System in an ICU.

RAPIDLab 1265 Blood Gas System

The RAPIDLab 1265 analyzer (Figure 2) offers a similar comprehensive menu and quick turnaround time for busy clinicians. By combining the longevity of Ready Sensor® electrode technology with the efficiency and ease of cartridge-based reagents, the RAPIDLab 1265 system optimizes operational performance in medium- to high-volume testing sites.

The measurement module in the RAPIDLab 1265 system comprises individual sensors developed for selectivity to the analyte of choice. Ready Sensor electrodes are aligned in the measurement module of the RAPIDLab 1265 system and constantly maintained at 37°C for optimum performance. Minimal sample volume requirements, advanced automatic quality control, fast calibration times, and hands-free, bio-safe sampling help improve workflow wherever critical care testing is performed.

Figure 2. RAPIDLab 1265 Blood Gas System in the NICU.

RAPIDLab 348EX Blood Gas System

Designed to deliver efficient critical care analysis in lower-volume testing sites, the RAPIDLab 348EX System (Figure 3) is a robust, cost-effective solution for smaller laboratories tasked with the challenge of performing fast-turnaround critical care tests. Fully automated operation supports low to medium throughput on an easy-to-use analyzer that is ready to generate accurate, on-demand results when clinicians need them, with a minimum of operator involvement.

Figure 3. RAPIDLab 348EX Blood Gas System in a laboratory.

epoc Blood Analysis System

The epoc Blood Analysis System (Figure 4) is a handheld, wireless solution that provides blood gases, a basic metabolic panel, hematocrit and lactate test results at the patient bedside in less than 1 minute after sample introduction. By incorporating a full critical care menu, including creatinine and BUN, on a single room-temperature-stable test card, the epoc system delivers an efficient and easy-to-manage patient-side testing program for the hospital.

Figure 4. epoc Blood Analysis System at the patient-side.

Atellica CH 930 Clinical Chemistry Analyzer

The Atellica CH 930 Analyzer (Figure 5) is the ideal solution for mid- to high-volume sample analysis within the laboratory, with the ability to perform up to 1800 tests per hour. The fully automated system offers an extensive menu and high throughput to meet the turnaround time demands of the busiest laboratories.

Figure 5. Atellica CH 930 Analyzer in the central laboratory.

Materials and Methods

This study investigated the accuracy of whole blood analyte measurement across the full Siemens Healthineers blood gas analyzer portfolio compared to that of the RAPIDLab 1265 system and to plasma analyte measurement for common measurands on the Atellica CH 930 chemistry system.

Two of each blood gas system were set up on individual benches designated Bench #1 and Bench #2 and located in close proximity at the Siemens Healthineers Edgewater facility (Table 1).

Table 1. Blood gas analyzer bench setup.

Bench #1	Bench #2
RAPIDLab 1265 system #1	RAPIDLab 1265 system #2
RAPIDPoint 500e system #1	RAPIDPoint 500e system #2
RAPIDLab 348EX system (with chloride) #1	RAPIDLab 348EX system (with chloride) #2
RAPIDLab 348EX system (with ionized calcium) #1	RAPIDLab 348EX system (with ionized calcium) #2
epoc system #1	epoc system #2

Further whole blood testing on two additional epoc Blood Analysis Systems was performed at the Siemens Healthineers facility in Ottawa, Canada, for the BUN and creatinine measurands. One Atellica CH 930 Analyzer, located at the Siemens Healthineers Glasgow, Delaware, facility, was used for the plasma testing. The measurands tested on each Siemens Healthineers platform are identified in Table 2.

Table 2. Measurand by platform for comparisons.

	RL348EX	RP500e	epoc	RL1265	RL348EX	RP500e	epoc
Measurand	vs RL1265			vs Atellica CH 930			
pH	X	X	X				
pCO_2	X	X	X				
pO_2	X	X	X				
Na^+	X	X	X	X	X	X	X
K^+	X	X	X	X	X	X	X
Ca^{2+}	X	X	X				
Cl^-	X	X	X	X	X	X	X
Glu		X	X	X		X	X
Lac		X	X	X		X	X
Crea							X
BUN							X

The design of the study indicated a minimum of 40 samples, excluding outliers, and preferably 100 samples to be analyzed in duplicate for each measurand. Fresh whole blood was collected in lithium heparin tubes on each day of the study. Over the course of 16 days, samples were assayed across two of each blood gas analyzer—the RAPIDPoint 500e, RAPIDLab 1265, RAPIDLab 348EX, and epoc systems—in normal syringe mode. The first replicate of each sample was tested on Bench #1 on each blood gas system in random order; the second replicate of each sample was tested on Bench #2 on each blood gas system, also in random order. The samples were then centrifuged, and the resulting plasma removed and stored in a temperature control device at -20˚C. The frozen plasma samples were subsequently thawed and tested on one Atellica CH 930 chemistry system. With three exceptions, only the first replicate was used for the analysis of the data. In the event that the results using the first replicate tested did not meet the study goal, the second replicate was evaluated and reported. The performance of each system was verified daily with quality control materials, and the same lot numbers of reagents and sensors were used for each platform type throughout the testing process.

All measurement procedure comparisons were performed in accordance with the CLSI EP09c guideline.[5] Correlation statistics, including slope (m), intercept (b), and coefficient of determination (r^2) as determined by Ordinary Deming, Weighted Deming, or Passing-Bablok regression analysis were calculated. Bias at a minimum of two MDLs was also calculated.

Results

Measurement procedure comparison statistics for the epoc, RAPIDPoint 500e, and RAPIDLab 348EX blood gas systems (y) versus the RAPIDLab 1265 blood gas system (x) are summarized in Table 3. Scatter plots for each measurand with the identity line (y = x) are depicted in Figures 6 through 14.

Table 3. Summary statistics for the epoc, RAPIDPoint 500e, and RAPIDLab 348EX Blood Gas Systems vs the RAPIDLab 1265 Blood Gas System.

Comparison	Measurand	n	Slope	Intercept	r^2	Regression	MDL	Bias
epoc Blood Analysis System vs RAPIDLab 1265 Blood Gas System	pH (units)	126	1.00	–0.013	0.994	Weighted Deming	7.3	–0.011
							7.5	–0.011
	pCO_2 (mmHg)	129	0.99	2.0	0.988	Weighted Deming	30	1.7
							50	1.5
	pO_2 (mmHg)	125	1.03	–3.4	0.999	Passing Bablok	50	–2.0
							200	2.1
	Na^+ (mmol/L)	131	1.05	–6.2	0.947	Passing Bablok	130	–0.1
							150	0.9
	K^+ (mmol/L)	114	1.02	–0.15	0.991	Weighted Deming	3.0	–0.09
							6.0	–0.02
	Ca^{2+} (mmol/L)	129	1.10	–0.11	0.990	Passing Bablok	1.1	–0.01
							1.3	0.01
	Cl^- (mmol/L)	131	0.91	6.7	0.959	Ordinary Deming	90	–1
							110	–3
	Glucose (mg/dL)	126	1.05	–2.8	0.996	Weighted Deming	45	–0.4
							120	3.5
							180	6.6
	Lactate (mmol/L)	124	0.95	0.02	0.966	Weighted Deming	1.3	–0.05
							2.7	–0.13
RAPIDPoint 500e Blood Gas System vs RAPIDLab 1265 Blood Gas System	pH (units)	127	1.03	–0.247	0.996	Passing Bablok	7.3	–0.025
							7.5	–0.019
	pCO_2 (mmHg)	130	0.92	3.8	0.968	Passing Bablok	30	1.4
							50	–0.3
	pO_2 (mmHg)	124	1.00	–2.5	0.998	Passing Bablok	50	–2.5
							200	–2.5
	Na^+ (mmol/L)	131	0.95	5.9	0.986	Weighted Deming	130	–0.1
							150	–1.0
	K^+ (mmol/L)	117	0.96	0.20	0.994	Weighted Deming	3.0	0.06
							6.0	–0.07
	Ca^{2+} (mmol/L)	129	0.94	0.07	0.997	Ordinary Deming	1.1	0.01
							1.3	–0.01
	Cl^- (mmol/L)	131	0.92	5.1	0.977	Weighted Deming	90	–2
							110	–3
	Glucose (mg/dL)	123	1.00	0.6	0.994	Ordinary Deming	45	1
							120	1
							180	1
	Lactate (mmol/L)	128	0.91	0.10	0.955	Passing Bablok	1.3	–0.02
							2.7	–0.14
RAPIDLab 348EX Blood Gas System vs RAPIDLab 1265 Blood Gas System	pH (units)	115	0.98	0.104	0.998	Passing Bablok	7.3	–0.006
							7.5	–0.009
	pCO_2 (mmHg)	119	1.01	1.9	0.993	Weighted Deming	30	2.2
							50	2.3
	pO_2 (mmHg)	114	1.02	–2.4	1.000	Weighted Deming	50	–1.4
							200	1.5
	Na^+ (mmol/L)	123	0.96	8.1	0.994	Weighted Deming	130	3.0
							150	2.3
	K^+ (mmol/L)	105	0.99	0.14	0.992	Weighted Deming	3.0	0.11
							6.0	0.08
	Ca^{2+} (mmol/L)	103	1.12	–0.12	0.996	Weighted Deming	1.1	0.02
							1.3	0.05
	Cl^- (mmol/L)	122	0.94	4.5	0.962	Weighted Deming	90	–1
							110	–2

Measurement procedure comparison statistics for the aforementioned blood gas systems (y) versus the common measurands on the Atellica CH 930 chemistry analyzer (x) are summarized in Table 4. Scatter plots for each measurand with the identity line (y = x) are depicted in Figures 15 through 21.

Table 4. Summary statistics for the epoc, RAPIDPoint 500e, RAPIDLab 1265, and RAPIDLab 348EX Blood Gas Systems vs the Atellica CH 930 Analyzer.

Comparison	Measurand	n	Slope	Intercept	r^2	Regression	MDL	Bias
epoc Blood Analysis System vs Atellica CH 930 Analyzer	Na^+ (mmol/L)	131	1.08	−10.9	0.947	Passing Bablok	130	−0.8
							150	0.7
	K^+ (mmol/L)	123	1.02	−0.08	0.996	Weighted Deming	3.0	−0.02
							6.0	0.05
	Cl^- (mmol/L)	132	0.88	11	0.976	Passing Bablok	90	0
							110	−2
	Glucose (mg/dL)	125	1.03	−2.1	0.998	Ordinary Deming	45	−0.9
							120	1.2
							180	2.8
	Lactate (mmol/L)	135	0.96	−0.02	0.971	Passing Bablok	1.3	−0.08
							2.7	−0.14
	BUN (mg/dL)	160	1.10	−1.0	0.992	Weighted Deming	6	0
							26	1
							50	4
	Creatinine (mg/dL)	161	1.04	−0.04	0.996	Weighted Deming	0.6	−0.02
							1.6	0.01
							6.0	0.17
RAPIDPoint 500e Blood Gas System vs Atellica CH 930 Analyzer	Na^+ (mmol/L)	131	0.99	0.8	0.976	Weighted Deming	130	−1.0
							150	−1.3
	K^+ (mmol/L)	122	0.95	0.29	0.997	Weighted Deming	3.0	0.14
							6.0	0.00
	Cl^- (mmol/L)	128	0.93	5.9	0.990	Passing Bablok	90	−1
							110	−2
	Glucose (mg/dL)	125	1.02	−1.8	0.994	Weighted Deming	45	−1.1
							120	0.1
							180	1.1
	Lactate (mmol/L)	137	0.81	0.32	0.956	Weighted Deming	1.3	0.07
							2.7	−0.20
RAPIDLab 1265 Blood Gas System vs Atellica CH 930 Analyzer	Na^+ (mmol/L)	132	1.02	−3.7	0.978	Ordinary Deming	130	−0.9
							150	−0.5
	K^+ (mmol/L)	113	1.00	0.07	0.994	Weighted Deming	3.0	0.07
							6.0	0.07
	Cl^- (mmol/L)	130	1.00	1.3	0.960	Passing Bablok	90	1
							110	1
	Glucose (mg/dL)	126	1.00	−1.0	0.996	Passing Bablok	45	−1.0
							120	−1.0
							180	−1.0
	Lactate (mmol/L)	137	0.90	0.24	0.979	Weighted Deming	1.3	0.10
							2.7	−0.04
RAPIDLab 348EX Blood Gas System vs Atellica CH 930 Analyzer	Na^+ (mmol/L)	121	1.00	2.0	0.984	Passing Bablok	130	2.0
							150	2.0
	K^+ (mmol/L)	105	0.99	0.22	0.994	Weighted Deming	3.0	0.18
							6.0	0.15
	Cl^- (mmol/L)	121	0.92	7.4	0.988	Passing Bablok	90	0
							110	−2

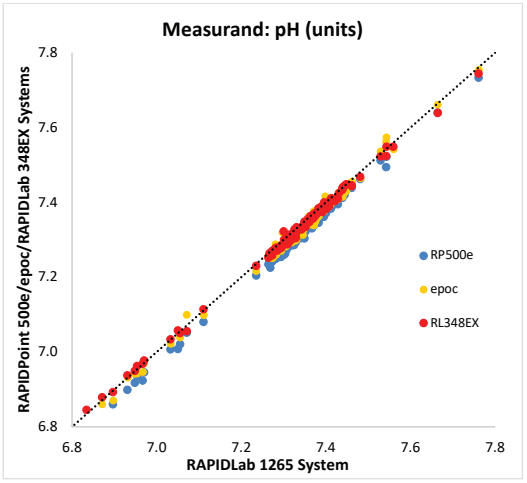

Figure 6. pH: RAPIDPoint 500e/epoc/RAPIDLab 348EX systems vs RAPIDLab 1265 system.

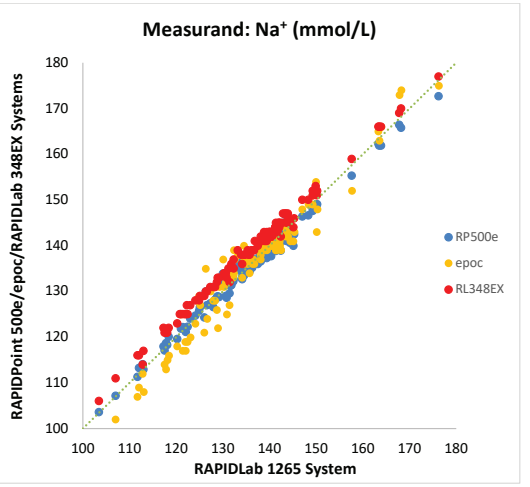

Figure 9. Na^+: RAPIDPoint 500e/epoc/RAPIDLab 348EX systems vs RAPIDLab 1265 system.

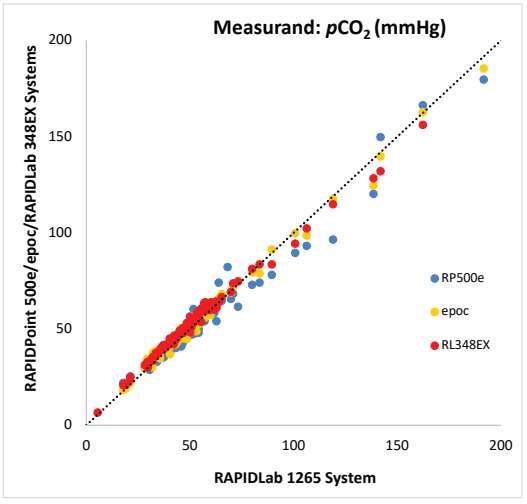

Figure 7. pCO_2: RAPIDPoint 500e/epoc/RAPIDLab 348EX systems vs RAPIDLab 1265 system.

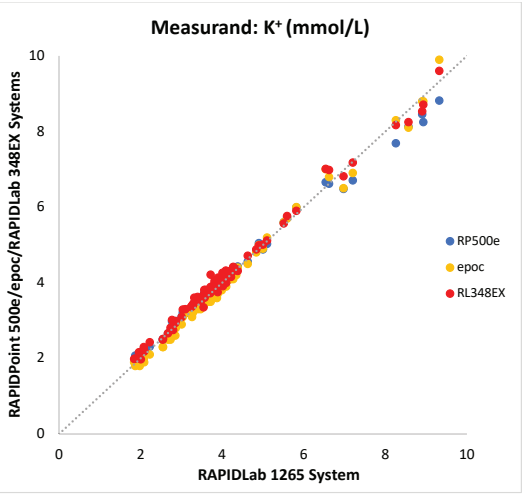

Figure 10. K^+: RAPIDPoint 500e/epoc/RAPIDLab 348EX systems vs RAPIDLab 1265 system.

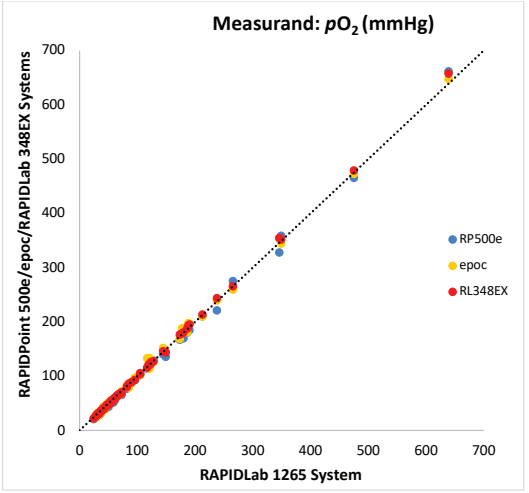

Figure 8. pO_2: RAPIDPoint 500e/epoc/RAPIDLab 348EX systems vs RAPIDLab 1265 system.

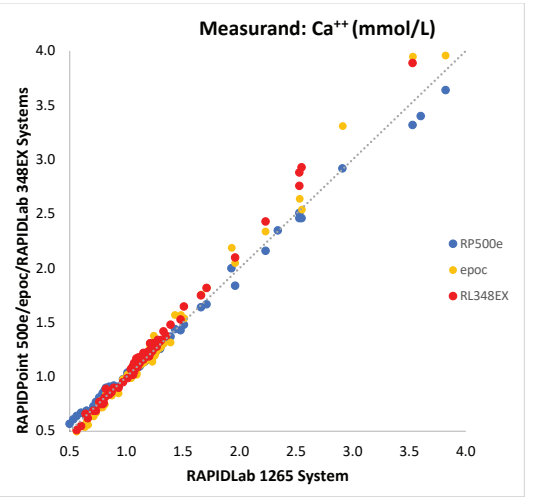

Figure 11. Ca^{++}: RAPIDPoint 500e/epoc/RAPIDLab 348EX systems vs RAPIDLab 1265 system.

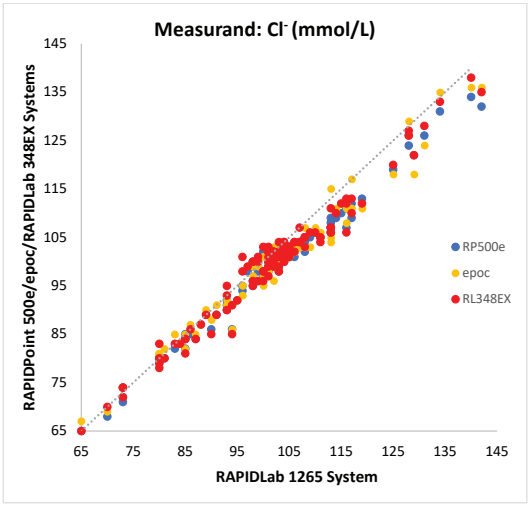

Figure 12. Cl^-: RAPIDPoint 500e/epoc/RAPIDLab 348EX systems vs RAPIDLab 1265 system.

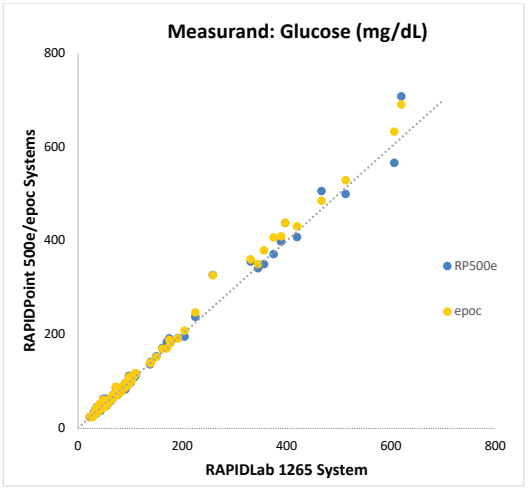

Figure 13. Glucose: RAPIDPoint 500e/epoc systems vs RAPIDLab 1265 system.

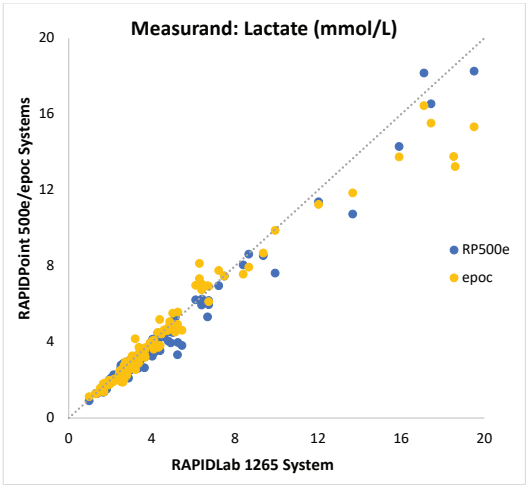

Figure 14. Lactate: RAPIDPoint 500e/epoc systems vs RAPIDLab 1265 system.

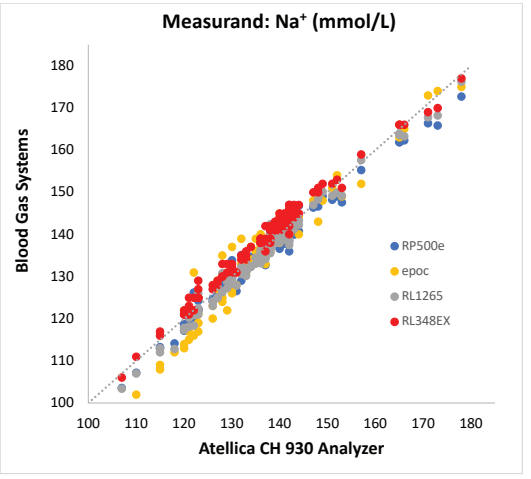

Figure 15. Na^+: Blood gas systems vs Atellica CH 930 Analyzer.

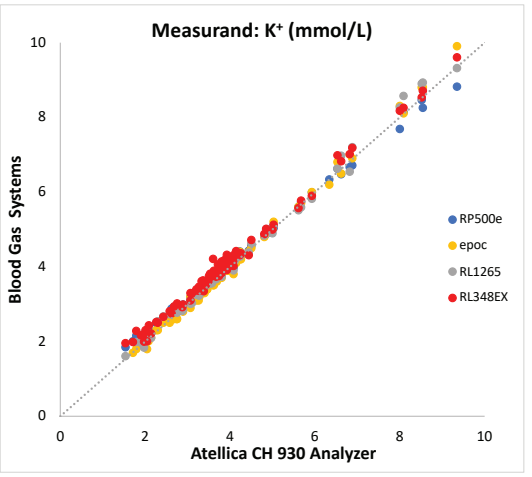

Figure 16. K^+: Blood gas systems vs Atellica CH 930 Analyzer.

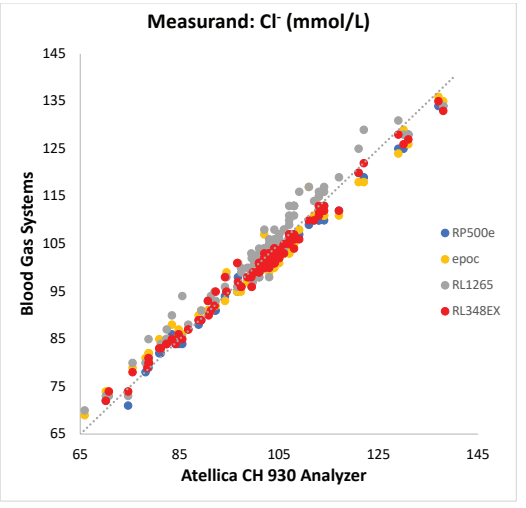

Figure 17. Cl^-: Blood gas systems vs Atellica CH 930 Analyzer.

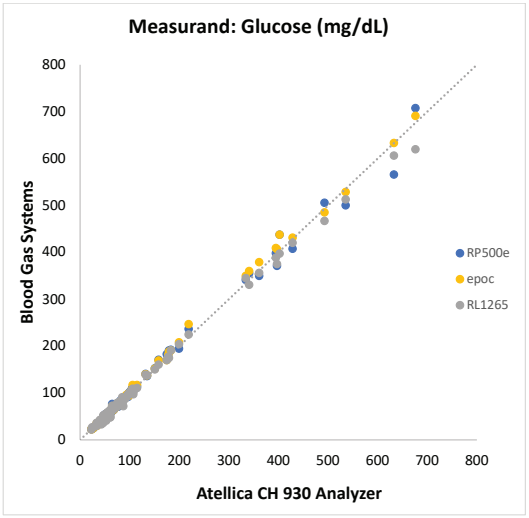

Figure 18. Glucose: Blood gas systems vs Atellica CH 930 Analyzer.

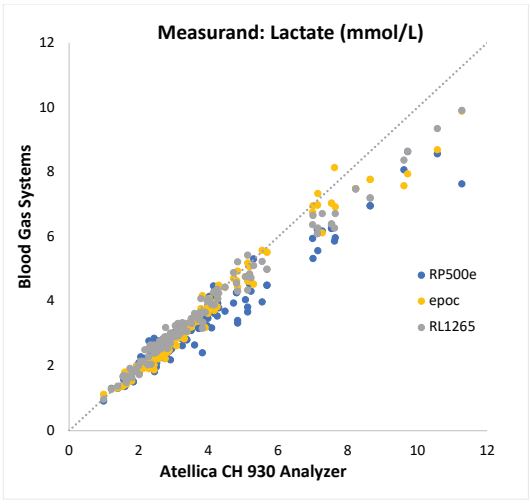

Figure 19. Lactate: Blood gas systems vs Atellica CH 930 Analyzer.

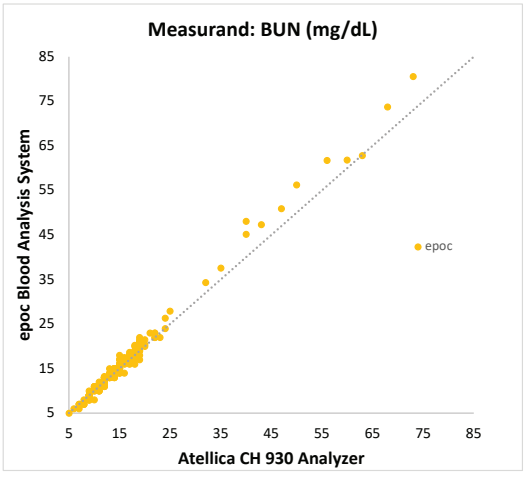

Figure 20. BUN: epoc Blood Analysis System vs Atellica CH 930 Analyzer.

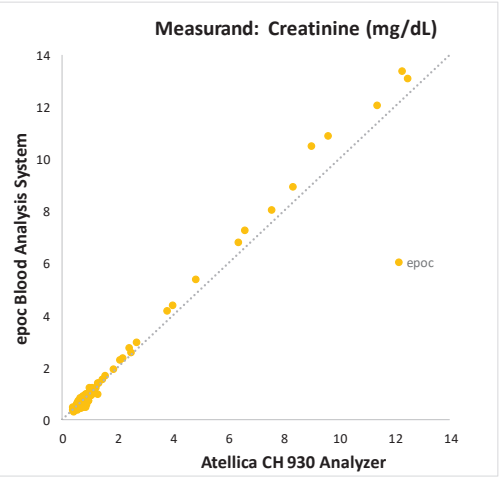

Figure 21. Creatinine: epoc Blood Analysis System vs Atellica CH 930 Analyzer.

Discussion

The analysis outcome in terms of the slope and coefficient of determination (r^2) is reported for each measurement procedure comparison. The desired slope across the common measuring interval is 0.90 to 1.10 for each comparison. The bias at the MDLs was also calculated for each comparison.

For blood gas system performance, the results of the study demonstrated that the desired outcome was obtained for all parameters, with the exception of ionized calcium on the RAPIDLab 348EX system vs RAPIDLab 1265 system, with a slope of 1.12. The coefficient of determination (r^2) of 0.996 obtained for ionized calcium indicates that the regression model explains 99.6% of the variability in the response data. The software option available on the RAPIDLab 348EX system allows for the entry of the slope and intercept coefficients, thereby offering improved correlation of ionized calcium results compared to the RAPIDLab 1265 analyzer when the coefficients are applied.

For blood gas system performance versus the Atellica CH 930 Analyzer, the results of the study revealed that the desired outcome was obtained for the common measurands with the exception of chloride on the epoc system and lactate on the RAPIDPoint 500e system. The slope obtained for chloride (epoc system versus Atellica system) was 0.88, however, the coefficient of determination (r^2) was 0.976, which suggests that the model explains 97.6% of the variability in the response data. Using the regression estimates for slope and intercept, the expected epoc system results for the biases and percent biases at the MDLs were calculated versus the Atellica analyzer. The percent biases at the two MDLs were 0.4% and –1.9%, indicating comparable performance on the two platforms at the MDLs. The slope obtained for lactate on the RAPIDPoint 500e system versus the Atellica analyzer was 0.81. The coefficient of determination was 0.956, which suggests that the model explains 95.6% of the variability in the response data. Using the regression estimates for slope and intercept, the expected RAPIDPoint 500e system results for the biases and percent biases at the MDLs were calculated versus the Atellica system. The percent biases at the two MDLs were 5.1% and –7.5%, indicating similar performance on the two platforms near the low end. A slope and offset may be applied in the RAPIDPoint 500e system software for improved correlation to the Atellica CH 930 Analyzer.

Conclusions

Harmonization at clinically relevant medical decision levels was demonstrated for a true end-to-end solution across all of the Siemens Healthineers blood gas systems and the recently released Atellica CH 930 Analyzer for common analytes.

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