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ARTERIALBLOODGAS ANALYSER ELECTROLYTES VERSUS SERUM ELECTROLYTES: A COMPARATIVE STUDY

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ABSTRACT

The importance of electrolyte balance in determining the prognosis of the patient cannot be underestimated. Electrolytes are important for optimum cellular functioning in most tissues of the body. Most of the metabolic processes depend on the electrolyte balance. Imbalance in the electrolyte concentrations can be either the cause or the consequence of many disorders, therefore such problems need to be identified promptly to ensure adequate treatment. Electrolyte imbalance can cause significant risks to life Measurement of electrolytes is of critical importance in the Intensive care units also So the electrolyte analysis by the laboratory should not only be accurate but also quick as timely corrections of the imbalance can greatly affect the patient's outcome Routinely serum electrolytes are analysed in the laboratory using Auto analysers which are very accurate but take atleast a minimum of 15 minutes to be reported. Electrolytes can also be measured in heparin blood using stand alone ABG analysers In this study we compare the measurement of electrolytes by these two methodologies Our aim was to explore the possibilities of using both interchangeably taking into account preanalytical factors also. We used Ortho Clinical Diagnostics Vitros 5600 Dry chemistry Auto analyser for serum elctrolytes and the Roche diagnostics Cobas b121: Analyser for measuring blood gases. Comparison between the two methodologies was figuratively represented in Bar diagrams and Line diagrams. Statistical analysis was done by using Passing-Bablock regression analysis in the method validator tool. The data was represented in the form of difference plots and scatter diagrams. The “t” value for Sodium. Potassium, Chlorideswere-3.0342;-4.7271;0.3502 respectively It is observed that the correlation is not acceptable as per Kendall"s Tau Correlation (0.9724) for sodium(0.887) and potassium (0.900), though it was found acceptable for chlorides(0.981)For all the three electrolytes the two-tailed P value equals 1.0000 By conventional criteria, this difference is considered to be not statistically significant We recommend that both the methodologies cannot be used interchangeably. Even though ABG electrolytes can be relied upon in emergencies it is always advisable to confirm the results with serum electrolytes analysed in Auto analysers upon stabilisation of the patient’s condition

KEYWORDS: *ABG Electrolytes, Serum electrolytes, Ion selective electrode*

INTRODUCTION

Electrolytes are very important for the continuation of the physiological functions of the human body. They play vital roles in: regulation of the cell membrane potential, steady process of neurohormonal pathways, energy transformation and the fluid, and acid-base balance in the body [1] In recent studies,[2-4] it is shown that in ICU patients, serum sodium and potassium levels are important predictors of mortality. Electrolyte values are routinely measured for all critical patients who are in the emergency department, for patients receiving fluid therapy, and for patients admitted to intensive care units (ICU).Incorrect sodium results can lead to inappropriate fluid administration which can result in hypernatremia. One of the important reversible cause of cardiac arrest is abnormalities in potassium concentrations. Bradycardia and asystole can be caused by hyperkalemia and cardiac arrhythmias can be caused by hypokalemia. Fluctuation in potassium is also well-documented during the course of cardiac resuscitation Accurate estimation of electrolytes has gained importance in diagnosis of etiology of various diseases as it is used to calculate anion gap. The turnaround time (TAT) for electrolytes should be kept as minimum as possible, so that early management of electrolyte abnormalities can be initiated.[5] Electrolyte values are measured both by arterial blood gas (ABG) analyzers and central laboratory auto-analyzers (AA), with the ABG giving faster results than the AA. Routinely, all electrolytes are measured from serum by the auto-analyzers (AA) available in central laboratories of hospitals, and the sample used for ABG is heparinised whole blood. However the results from AA are time consuming with a minimum of atleast 15 minutes. This includes the time taken for serum separation also by centrifugation Quick decisions that need to be made depending on electrolyte values hence are often made either blindly or are delayed. Arterial Blood gas analyzers use the direct ISE method with short processing time that provides time and rapidity to the physician in the patient's treatment decisions[6] and there is no need for separation of samples as heparinised whole blood is used in ABG analysers. Usually the immediate assessment of the electrolytes is done by ABG analysers followed by sending samples to the central laboratory for assessment of serum electrolytes. The apparent inter changeability in the use of ABG and central laboratory analyzers to measure electrolytes increases the variability of test results; the reliability and validity of such data require examination.[7] The objective of our study is to investigate whether electrolyte levels measured by using blood gas analyzers (ABG) and auto-analyzers (AA) are equivalent and can be used interchangeably.

MATERIALS AND METHODS

A retrospective comparison study was done for 50 patients The patients whose serum samples and heparinised arterial samples were drawn at the same time and sent to the laboratory were chosen for study. The electrolytes were measured in heparinised arterial samples in cobas b 121 ABG analyser by Roche Diagnostics and serum samples in OCD Vitros 5600 auto analyser The principles of analyses in ABG analyser are as follows: Sodium electrode uses a sodium sensitive glass capillary. Readings of this electrode are compared to the reference electrode to obtain a sodium concentration. Potassium electrode uses a modified valinomycin electrode with a membrane of plasticised PVC to generate a signal when potassium moves from the sample to the membrane boundary layer. Chloride electrode is a modification of the potassium electrode , using a chloride sensitive ion exchanger instead of valinomycin All electrolyte electrodes use the reference electrode as a baseline.[8] In Vitros 5600, the Vitros chloride slide is a multilayered analytical element coated on apolyester support that uses direct potentiometry for measurement of chloride ions. The slide consists of two ion selective electrodes each containing a protective layer, a reference layer, a silver layer and a silver chloride layer coated on a polyester support. A drop of patient sample and a drop of reference fluid on separate halves of the slide results in migration of both fluids towards the centre of the paper bridge .A stable liquid junction is formed that connects the reference electrode to the sample electrode. Each electrode produces an electrochemical potential in response to the activity of the chloride ions applied to it .The potential difference between the two electrodes is proportional to the concentration of chloride in the sample. The ion selective electrodes for sodium and potassium are methyl monensin {an ionophore for sodium}, and valinomycin respectively.[9] The values obtained are tabulated in Table I as follows:

Table 1
Comparison of electrolytes in ABG and serum samples

	Sodium		Potassium		Chloride	
S.no	**ABG**	**serum**	**ABG**	**serum**	**ABG**	**serum**
1	137.9	139	3.36	3.3	102	103
2	132.9	137	2.83	3	92	86
3	139	140	4.03	4.6	101.2	102
4	131.2	131	4.53	4.8	101.5	103
5	137.4	139	3.49	3.7	103.5	104
6	139.2	140	2.99	3.5	97.6	95
7	138.5	139	3.73	3.9	99.5	98

8	123.7	127	3.08	3.2	79.6	74
9	140.6	142	4.45	4.2	114.1	121
10	129.6	131	4.42	4.7	99	102
11	138	142	3	3.2	94.9	93
12	130	137	3	3.4	93.7	89
13	138.8	141	3.75	4.3	100.5	102
14	145	144	4.57	4.5	115.5	121
15	136.9	137	3.34	3.5	103	104
16	138.4	138	2.88	3.6	95.9	93
17	135.2	139	4.16	4.2	99.4	97
18	142.9	146	3.66	4	108	109
18	129.9	132	3.45	3.6	97.6	98
20	136.7	142	4.81	5.7	105.2	106
21	139.2	143	3.43	3.7	96.5	97
22	137.4	141	3.29	3.2	103.6	106
23	131.2	133	3.19	3.3	102.9	98
24	129.4	130	3.29	3.5	95	94
25	157.9	161	4.24	5.3	121.7	124
26	159.5	162	4.69	4.7	121.9	126
27	129.5	133	4.49	5.2	94.3	92
28	141.2	143	3.45	4	106.9	108
29	143	145	3.48	3.2	107.8	112
30	127.2	130	3.45	3.6	92.3	92
31	135.6	139	4.18	4.1	102.2	103
32	143.5	146	3.75	3.8	109.4	113
33	125.4	127	3.73	4.3	91.2	91
34	134.9	137	4.38	4.9	99.9	98
35	133.2	137	4.11	4.2	96.4	94
36	141.7	141	3.77	3.8	106.9	106
37	141	140	3.38	3.8	107.9	107
38	140	142	3.61	3.6	105.1	108
39	138.5	139	3.73	3.9	99.5	98
40	123.7	127	3.08	3.2	79.6	74
41	140.6	142	4.45	4.2	114.1	121
42	129.6	131	4.42	4.7	99	102
43	138	142	3	3.2	94.9	93
44	130.7	137	3	3.4	93.7	89
45	148.7	147	3.33	3.1	109.6	110
46	140.8	142	3.4	3.2	107.4	108
47	128.2	129	5.29	6.2	93.7	93
48	133.2	137	3.59	3.5	103.9	102
49	165.9	144	3.48	3.1	107.1	114
50	140.3	141	4.82	4.8	110	113

STATISTICAL ANALYSIS

The comparison between ABG and serum electrolytes was shown using bar diagrams and line diagrams Statistical analysis was done using Passing-Bablock regression analysis and 'r' value calculated by using the method validator tool version 1.19. The data was also represented in the form of scatter diagrams and difference plots. The mean, standard deviation, Zvalue were calculated by using Microsoft excel. That-value was calculated using the method validation tools in the Westgard QC portal. The P value was calculated using the Quick Calcs tool in the Graph pad software. The sodium comparison was shown in form of bar diagrams and line diagrams in the Illustration I and Illustration II respectively The Potassium comparison was shown in form of bar diagrams and line diagrams in the Illustration III and Illustration IV respectively The Chlorides comparison was shown in form of bar diagrams and line diagrams in the Illustration V and Illustration VI respectively The Passing Bablock regression analysis was shown in the Illustrations VII, VIII, IX for Sodium, Potassium and Chlorides respectively The scatter plots for Sodium , Potassium, Chlorides were shown in Illustrations X, XI, XII respectively

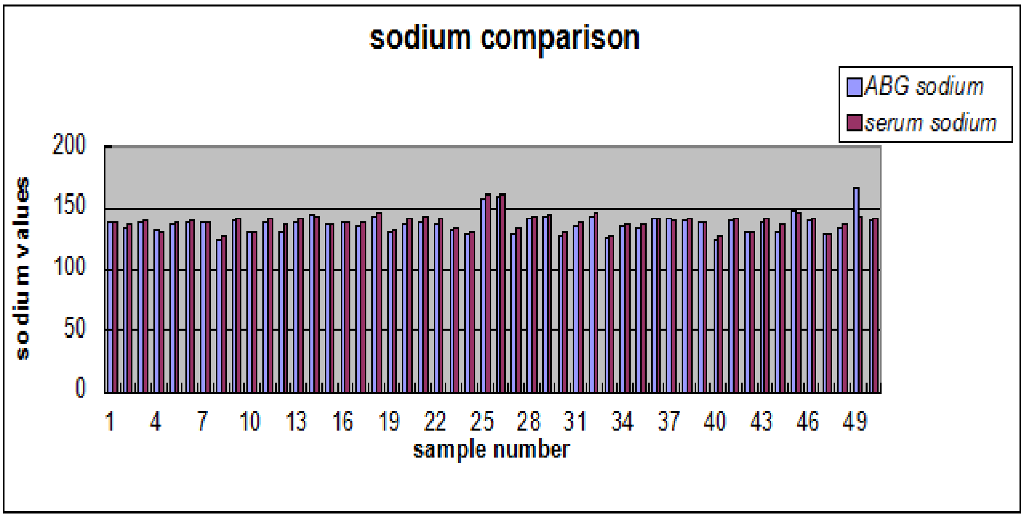

Illustration I
Bar diagram showing the comparison of Sodium in ABG and serum samples

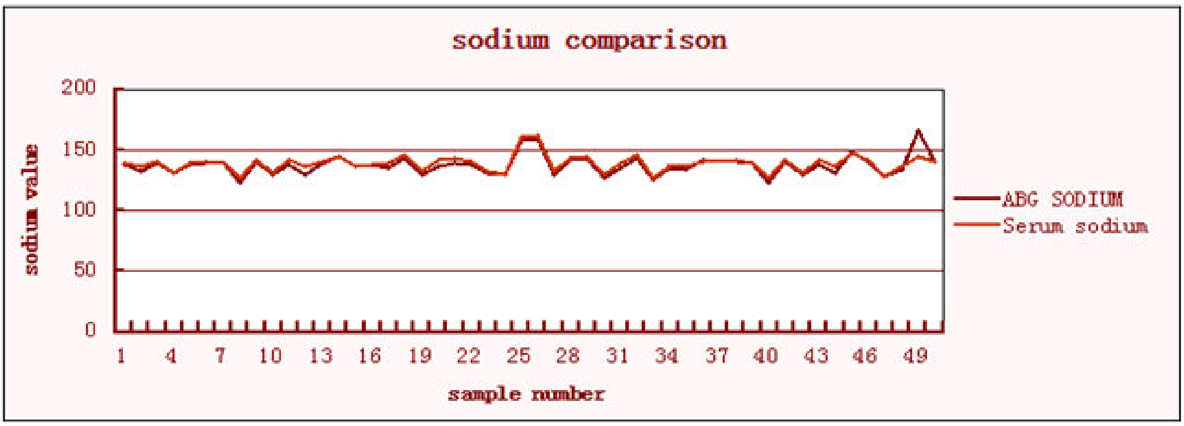

Illustration II
Line diagram showing the comparison of Sodium in ABG and serum samples

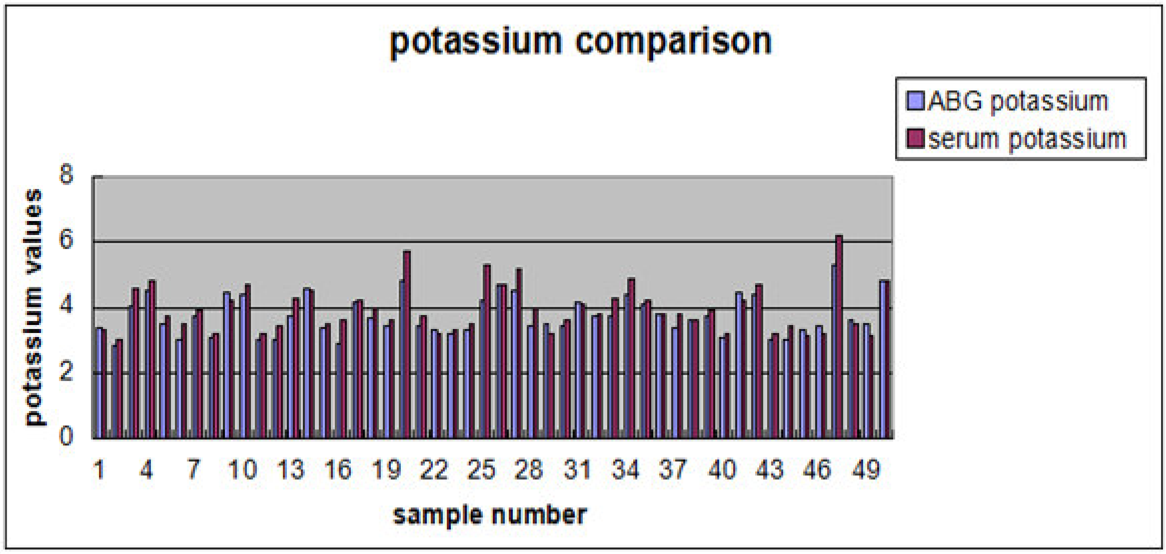

Illustration III

Bar diagram showing the comparison of Potassium in ABG and serum samples

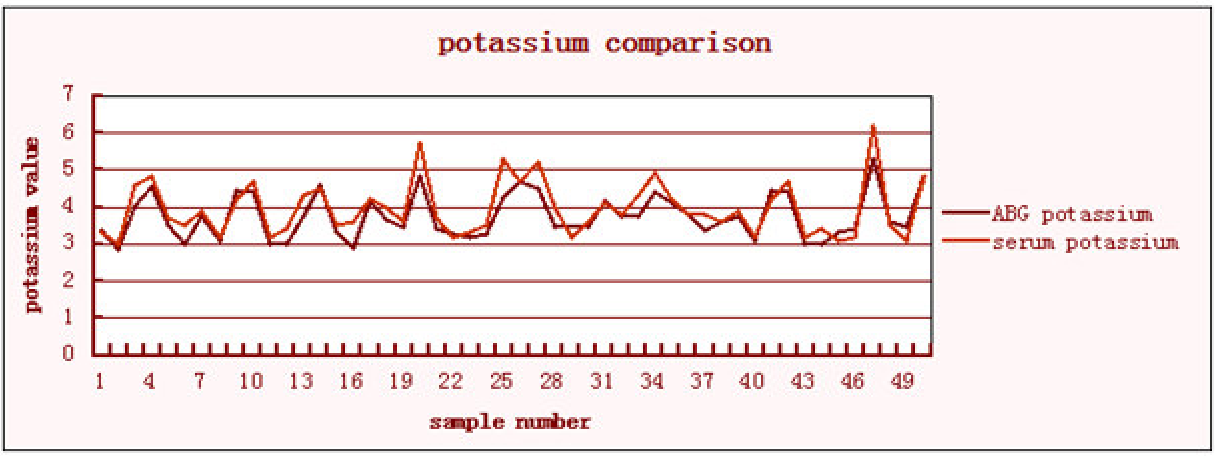

Illustration IV

Line diagram showing the comparison of Potassium in ABG and serum samples

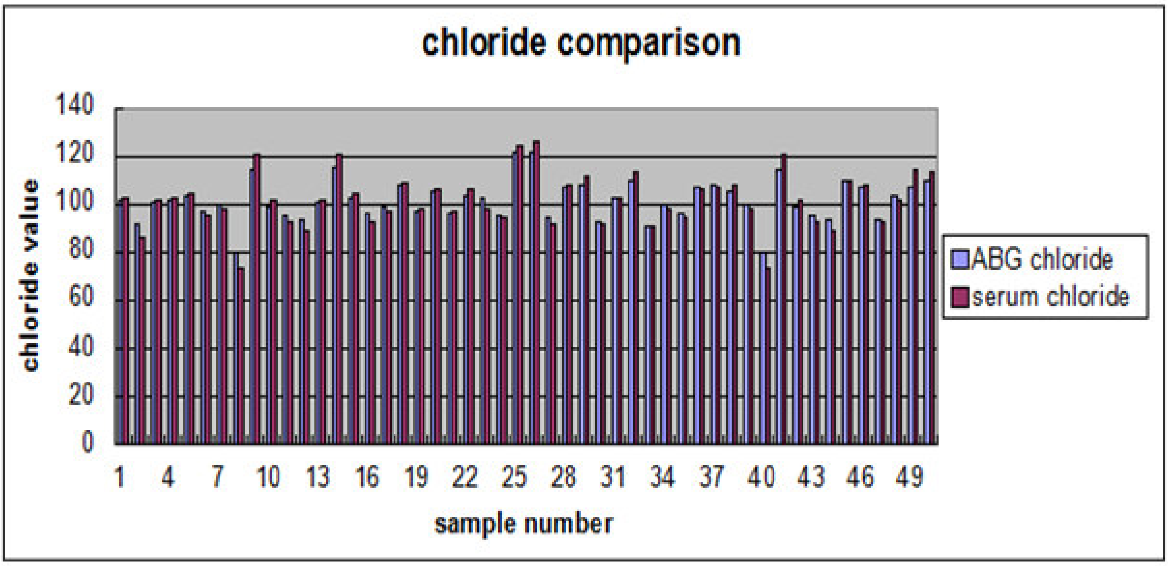

Illustration V

Bar diagram showing the comparison of Chloride in ABG and serum samples

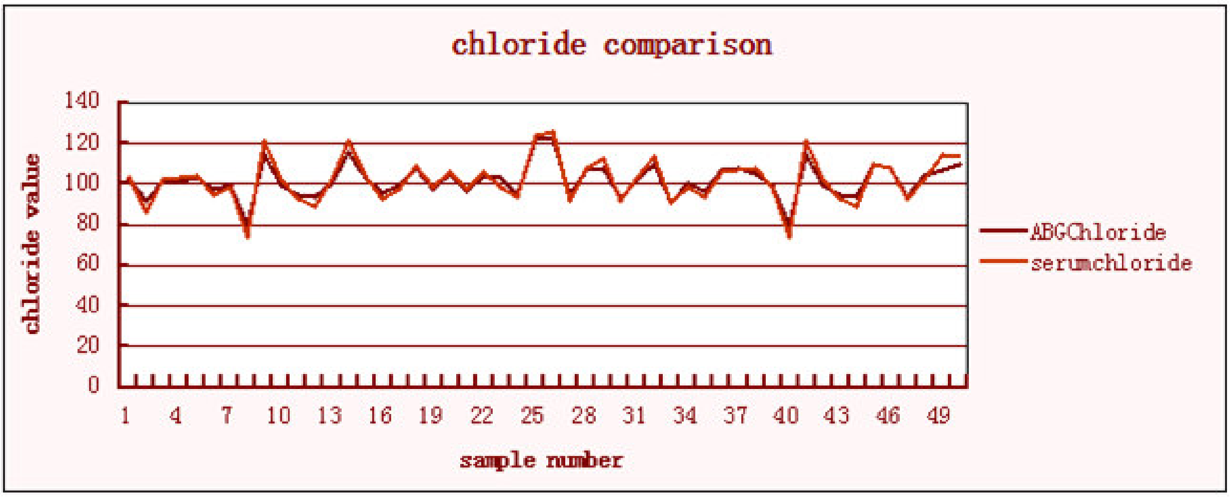

Illustration VI

Line diagram showing the comparison of Chloride in ABG and serum samples

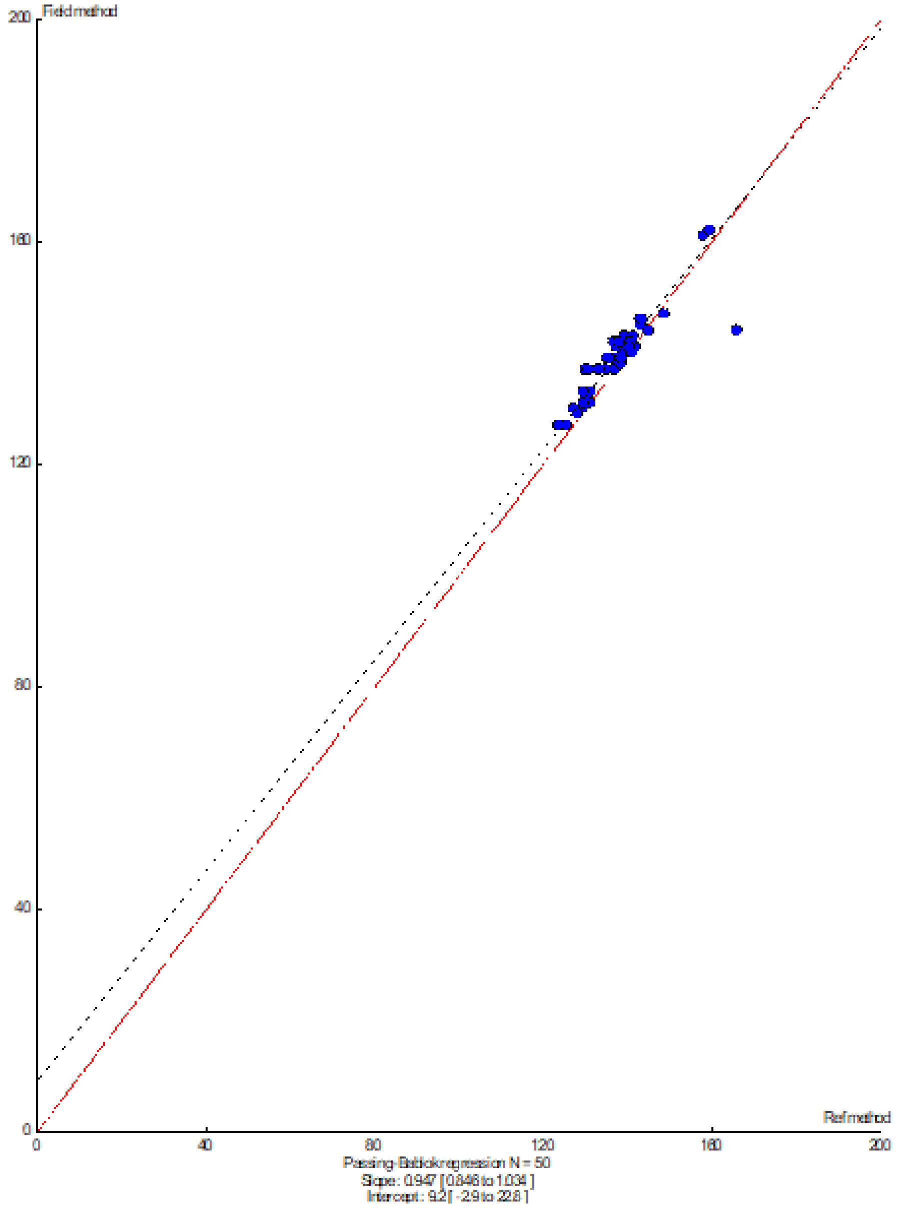

Illustration VII

Passing Bablock regression analysis-Sodium

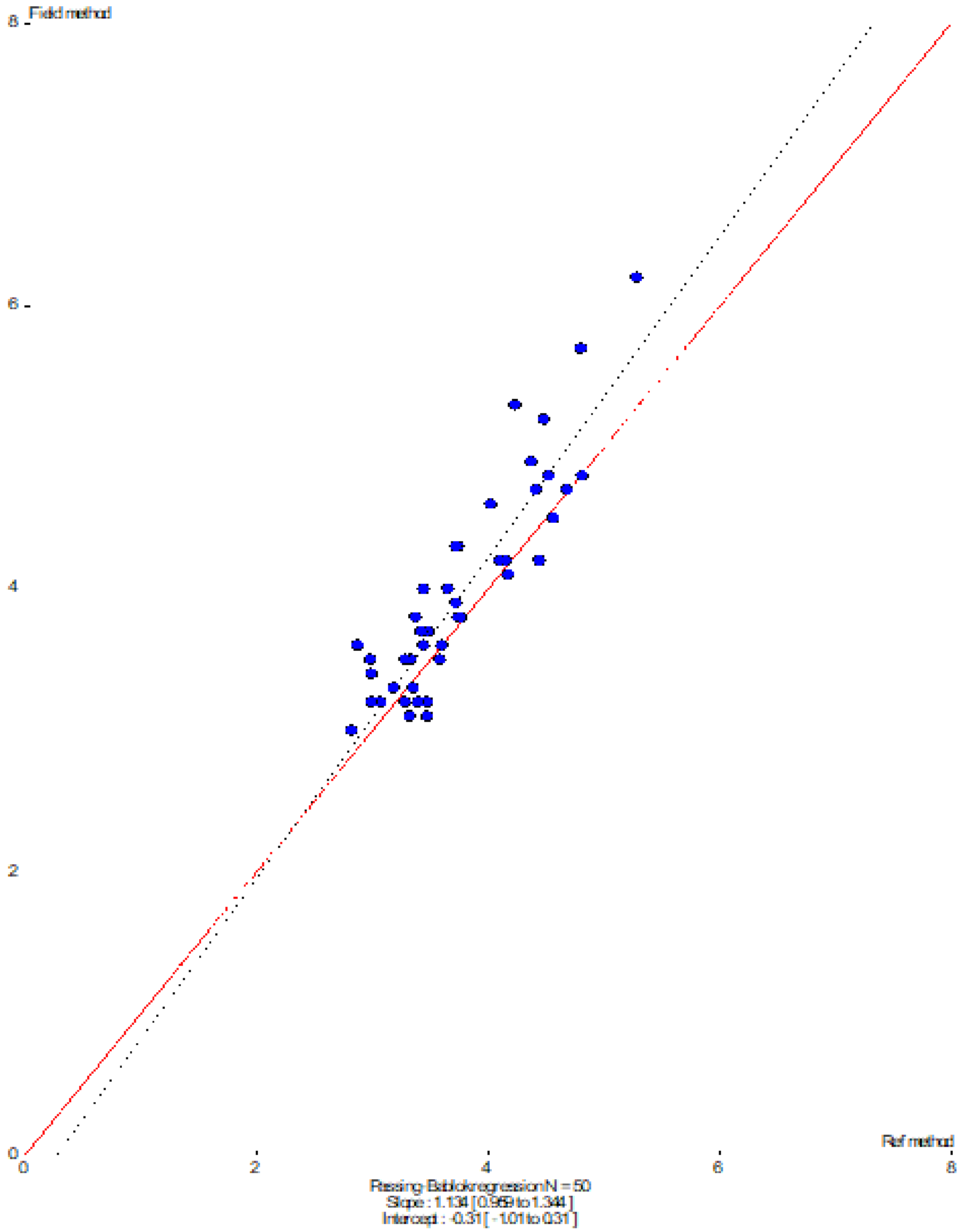

Illustration VIII

Passing Bablock regression analysis=Potassium

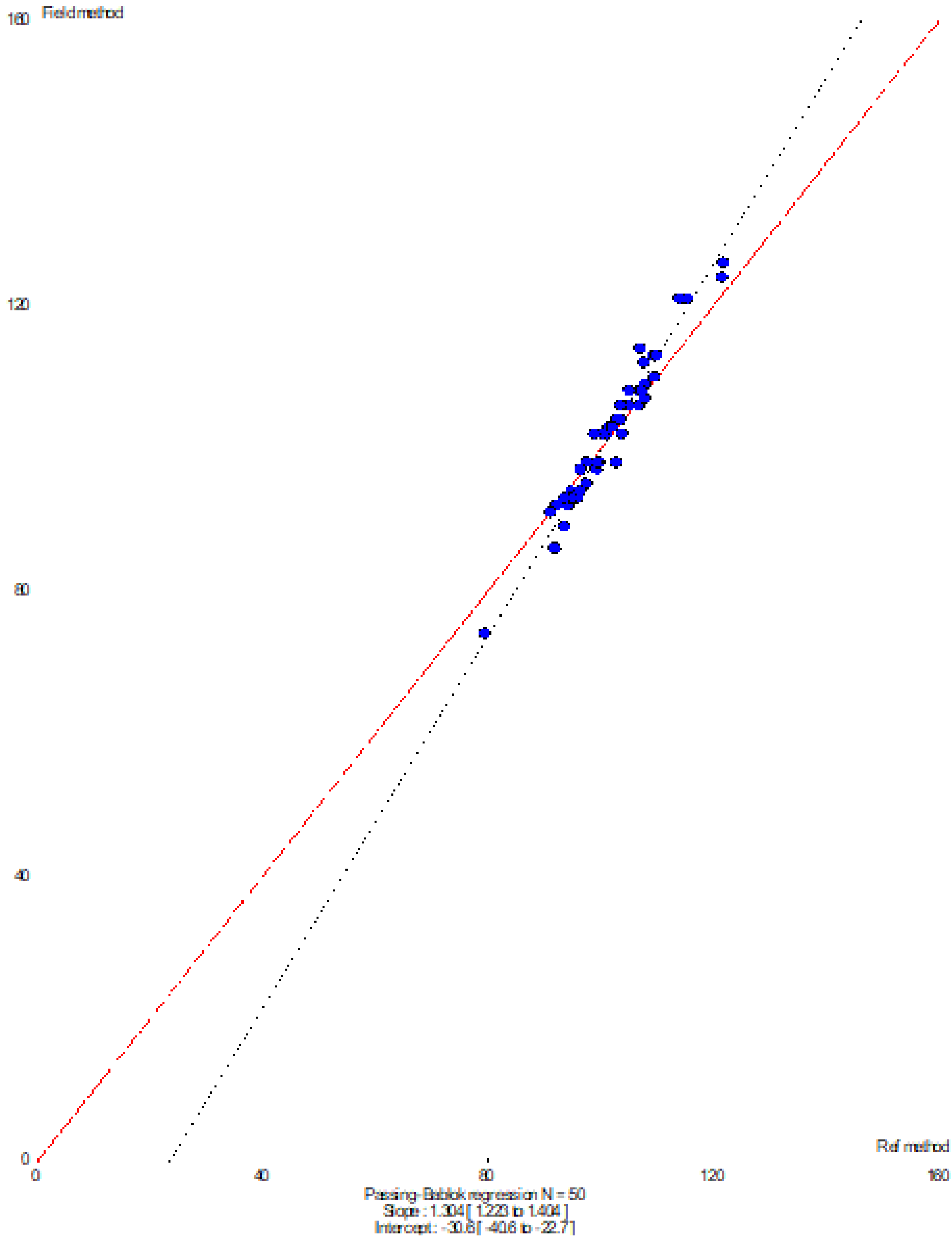

Illustration IX

Passing Bablock regression analysis-Chloride

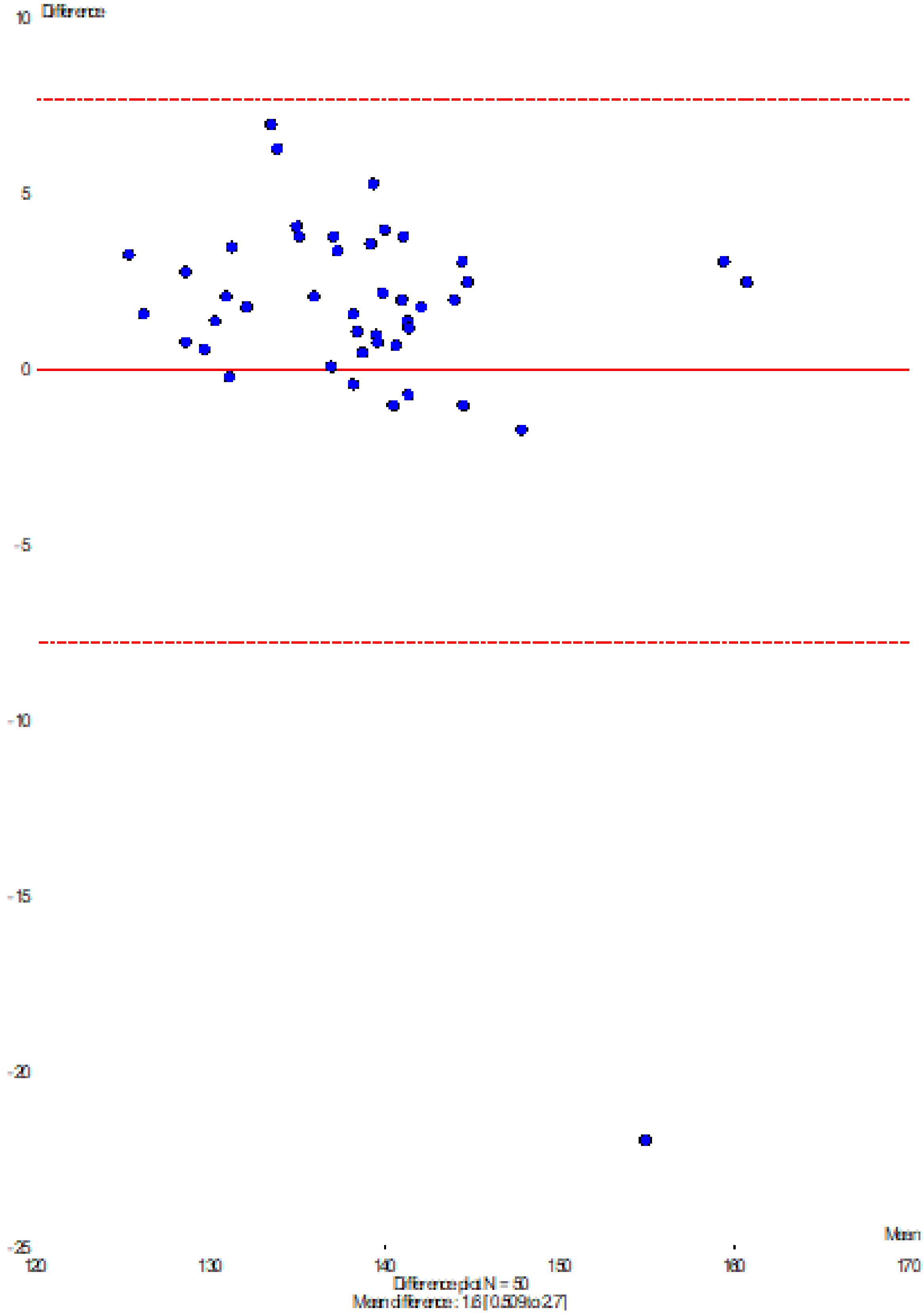

Illustration X
Scatter Plot -Sodium

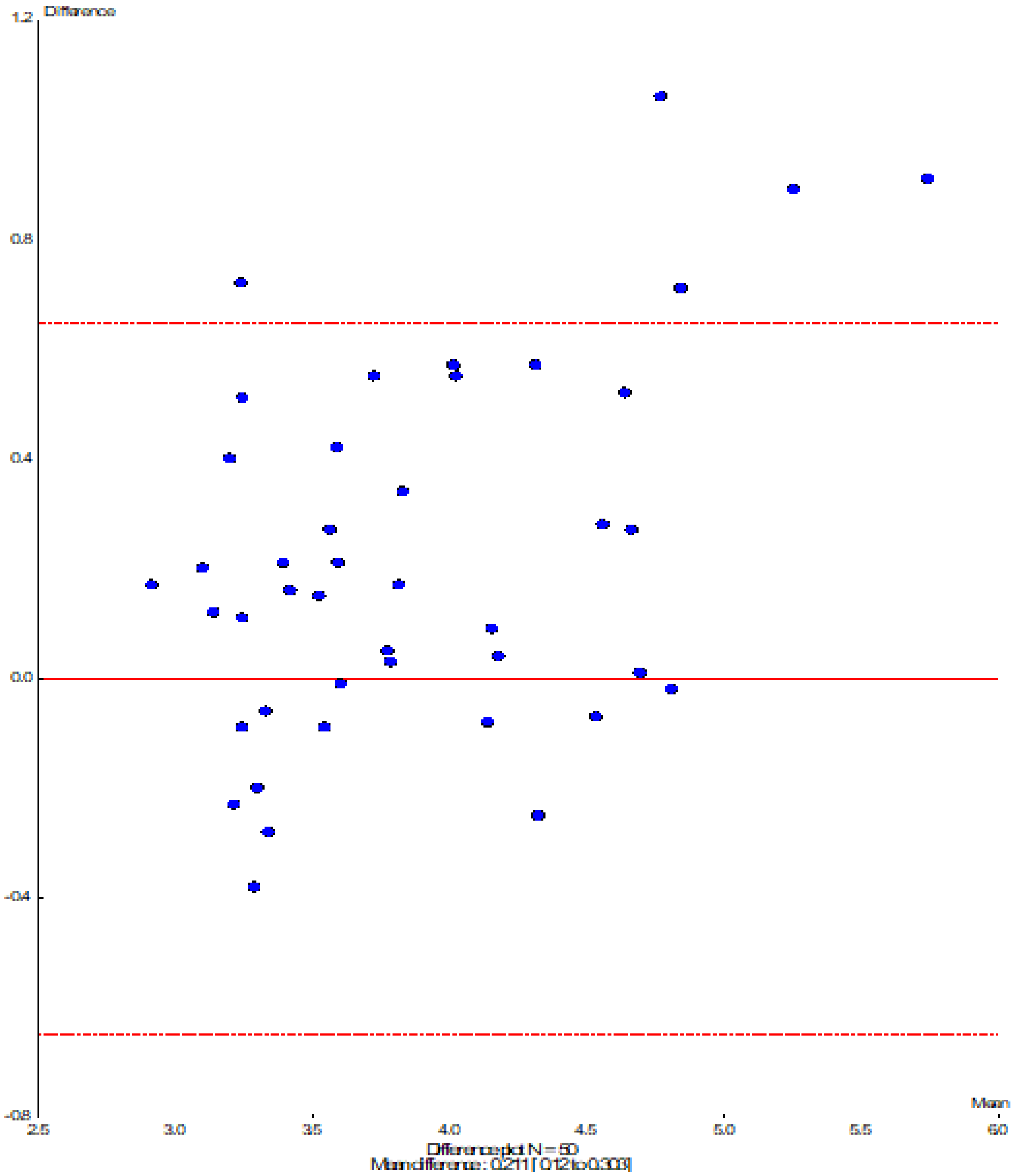

Illustration XI
Scatter Plot – Potassium

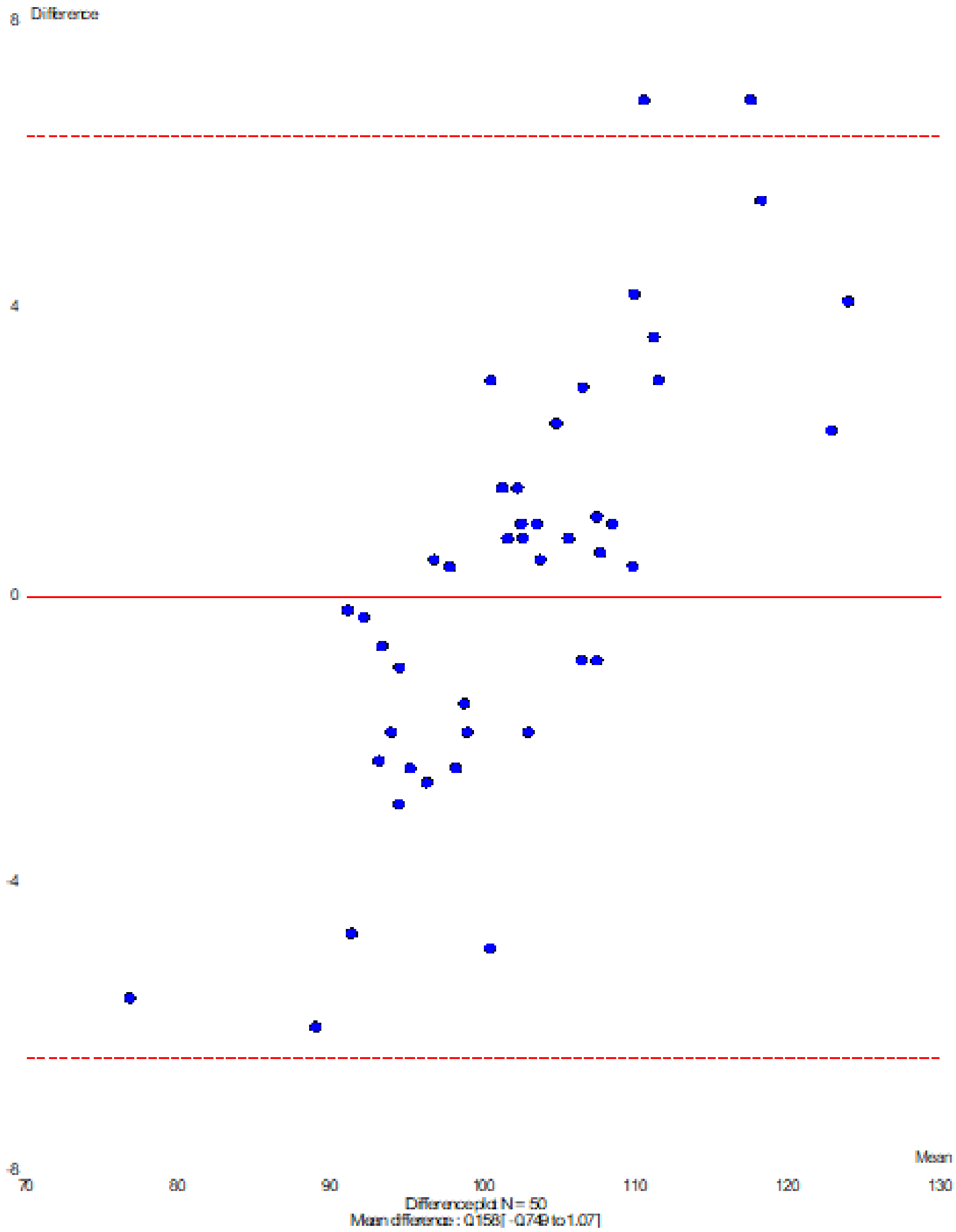

Illustration XII
Scatter Plot -Chloride

RESULTS

The slope and intercept were acceptable in Passing Bablock analysis for all the three electrolytes The r value was 0.887 for sodium;0.900 for potassium and 0.981 for chloride .It is observed that the correlation is not acceptable as per Kendall"s Tau Correlation (0.9724) for sodium and potassium. The 't' value was-3.0342 for Sodium, -4.7271 for Potassium, -0.3502 for Chlorides The mean, standard deviation of ABG sodium and serum sodium, Z value and P value , 't' value, 'r' value, slope and intercept were represented for Sodium, Potassium, Chlorides in the Table II, Table III, Table IV respectively For all the three electrolytes the two-tailed P value equals 1.0000 By conventional criteria, this difference is considered to be not statistically significant

Table II
ABG Sodium versus Serum Sodium

N	50
Mean for ABG sodium	137.416
Standard deviation for ABG sodium	8.29
Mean for serum sodium	139.02
Standard deviation for serum sodium	7.01
Z value for sodium	0
P value for sodium	1
t-value	-3.0342
r value	0.887
Slope	0.947 (0.846 to 1.234)
Intercept	9.2 (-2.9 to 22.8)

Table III
ABG Potassium versus Serum Potassium

N	50
Mean for ABG potassium	3.74
Standard deviation forABG potassium	0.604
Mean for serum potassium	3.952
Standard deviation for serum potassium	0.728
Z value for potassium	0
P value for potassium	1
t-value	-4.7271
r value	0.900
Slope	1.134 (0.969 to 1.344)
Intercept	0.31 (-1.01 to 0.31)

Table IV
ABG Chlorides versus Serum Chlorides

N	50
Mean for ABG chlorides	101.562
Standard deviation forABG chlorides	8.54
Mean for serum chlorides	101.72
Standard deviation for serum chlorides	11.10
Z value for chlorides	0
P value for chlorides	1
t-value	-0.3502
r value	0.981
Slope	1.304 (1.223 to 1.404)
Intercept	-30.6 (-40.6 to -22.7)

DISCUSSION

Ion selective electrodes (ISEs) are the most routinely used method for electrolytes estimation in clinical laboratories. There are two types of ISE measurements based on sample preparation. Devices based on direct measurement provide an undiluted sample to interact with ISE membrane.[10] These direct ISE based devices are typical of point of care testing analyzers, both bench top and portable.[6] The devices based on indirect ISE use a preanalytic dilution and are often employed in high throughput central laboratory automated analyzer[11] The most important factor which leads to difference in the results of Na + on ABG and laboratory Auto analyzer is predilution of sample in indirect ISE.[12] The overestimation is linked to serum protein and albumin levels. Story *et al*.[13] have reported that in indirect ISE there is an overestimation of Na in hypoalbuminemia. This difference in measurement between direct and indirect ISE results was found to correlate with serum albumin and total protein concentrations.[14] However this limitation was overcome as the Vitros 5600 dry chemistry auto analyser and the Roche ABG analyser in the study used a direct ISE. Previous studies that measured the accuracy of electrolyte values obtained by ABG machines concluded that the results from two different measurement technologies differed significantly for plasma sodium and chloride concentrations. Gupta et al concluded that the results of electrolytes on ABG and electrolyte analyzer cannot be used in inter-exchangeable manner and should be interpreted with caution. Their study emphasized that the results obtained are instrument specific.[15] Budak et al concluded that the ABG and AA do not yield equivocal Na+ and K+ data. Hormonisation between ABG and AA should be established prior to introduction of new ABG systems as ABG use is rising, particularly in ICUs, emergency departments, and operating theatres Emergency Physicians frequently rely on ABG test data but send an additional sample to the central laboratory. The apparent interchangeability in the use of ABG and central laboratory analyzers to measure electrolytes increases the variability of test results, the reliability and validity of such data requiring examination.[7] Jain et al found that there is no significant difference between the potassium values measured by the blood gas machine and the auto-analyzer. However, there is a difference between the measured sodium was found to be significant. They concluded that critical decisions can be made by considering the potassium values obtained from the arterial blood gas analysis.[16] Morimatzu et al concluded that results with the ABG and Autoanalyser differed significantly for plasma sodium and chloride concentrations. They further observed that these differences significantly affected the calculated Anion Gap values and might lead to error inclinicians to assessments of acid-base and electrolyte status.[17] According to a study by Chacko et al., there was a significant difference in the measured sodium levels between the 2 methods.[18] S Rajavi et al., observed an increase in the levels of sodium and potassium in serum when compared to sodium and potassium in arterial blood. According to their study, the lower arterial values could be explained by the dilutional effect of heparin since arterial samples are collected in heparinized syringes.[19] Electrolytes results on ABG can be significantly varied by inadequate mixing of the specimen with anticoagulant and thus varying the ratio of blood sample to anticoagulant. Other possible reasons could be use of conventional syringes which are flushed with liquid heparin which could lead to dilution of sample volume and thus cause negative biasin the estimation of electrolytes on ABG.[20]This limitation was overcome in this study by using electrolyte balanced lithium heparin coated syringes and samples taken by trained ICU staff. However even with the use of pre-heparinized syringes, lower than 5% bias was reported[21]. In serum samples, hemolysis caused a release of potassium and other intracellular components from the erythrocytes into the extracellular fluid, leading to elevated levels of serum potassium. Hemolysis might result from prolonged storage at low temperatures or a prolonged time between sampling and analysis, use of alcohol for disinfection, and inappropriate sampling needles. The factors mentioned above seem most likely to affect the potassium rather than the sodium levels[22] Abdullah et al., concluded that though the correlation between serum and arterial electrolytes was significant however, related to time it was weakly negative. They concluded that critical decisions can be made by considering values obtained through both ABG and Serum levels of the electrolytes[23]. Nanda et al. also found that arterial sodium and arterial potassium can be used in place of venous sodium and venous potassium levels in the management of critically ill patients.[24] Jain et al. found no significant difference between the potassium values measured by blood gas analyser and auto-analyzer, but significant difference between the measured sodium.[9] Yilmaz et al. concluded that critical decisions could be made by the potassium levels obtained from the ABG analyser, but a simultaneous follow-up sample had to be sent to the central laboratory for confirmation.[1] Uysal et al. concluded that there was a strong correlation for Arterial blood gas analyser measurements of hemoglobin, hematocrit, glucose, potassium, and sodium levels but were only moderate corelation for chloride levels. These parameters as measured by a blood gas analyzer can be use dreliably in critical decision making but require validation by core laboratory results.[25] Uyanik et al. found negligible difference in the Potassium values measured by ABG and core laboratory auto analysers and concluded that the parameters showed variable performances and not all tests were meeting the minimum performance goals. It is thus important that clinicians and laboratorians are aware of the limitations of their assays.[26.]

CONCLUSION

We conclude that the parameters showed variable performances and the electrolyte values from ABG equipments and Auto analysers cannot be used inter changeably. Though the ABG analysers offer an advantage of quick results, strict preanalytical considerations regarding transport of sample should be weighed in. Further, more collection of an arterial sample requires considerable care and experience from the phlebotomist. The autoanalysers using dry chemistry systems such as in our study, give fast and reliable results but the concerns about sample haemolysis and time taken for centrifugation always remains Therefore the clinicians and laboratory professionals should be aware of these shortcomings and interpret the results cautiously.

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CONFLICT OF INTEREST

Conflict of interest declared none.

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