Use of Rapid ABG Analyzer in Measurement of Potassium Concentration: Does It Agree with Venous Potassium Concentration?

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Background: *Because extreme venous potassium abnormality can be life threatening, rapid measurement of potassium level is essential. Traditional biochemical analysis for venous potassium takes time and delays management in seriously ill patients. Analysis form arterial blood gas (ABG) may be an alternative method that is faster.*
Objective: *To determine agreement between potassium obtained from venous and arterial blood gas in emergency patients, Siriraj Hospital.*
Material and Method: *Cross-sectional study performed in 53 patients who presented to the emergency department of Siriraj Hospital. Potassium level measured from ABG was compared to venous route.*
Results: *The mean of venous, arterial potassium and difference between each pair were 3.95, 3.46, and 0.49 mmol/L respectively. The Intraclass Correlation Coefficient between each pair of two methods and 95% CI of agreement were 0.904 and 0.839 to 0.943, $p < 0.01$.*
Conclusion: *The agreement between ABG and venous potassium measurement are confirmed. Clinicians can use ABG's potassium level as a guideline for treatment instead of using the conventional venous potassium level.*

Keywords: *Arteries, Blood gas analysis, Potassium*

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Potassium is a major intracellular ion and plays an important role in stabilizing cell membranes, which is essential for the proper functioning of the heart, kidneys, muscles, nerves, and digestive system. Potassium concentration abnormalities are considered life threatening conditions and may require urgent clinical intervention[1]. The status of intracellular metabolism has a major effect on this gradient, since the anoxic, damaged or glucose-depleted cell, leaks potassium at an accelerated rate[2-4]. Both hyperkalemia and hypokalemia cause fatal cardiac arrhythmias, bradycardia, asystole, and neuromuscular symptoms. Potassium abnormalities may need to be corrected rapidly, especially when the change in potassium levels occurs over a short period of time or in the presence of electrocardiographic changes. Biochemical analysis, especially for potassium concentration, is important to guide therapy in the treatment of seriously ill patients in the emergency department. This has traditionally been done by taking a venous sample and sending it to the biochemistry laboratory for standard analysis; however, this takes some time. Many people now prefer to measure potassium of an arterial blood gas sample in a resuscitation room based blood gas analyzer. This gives a much faster result, but it was previously unknown how accurate this method is when compared with a venous measurement.

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The aim of the present study was to determine the agreement between potassium concentrations measured on arterial blood, using a blood gas analyzer and venous blood, and by using a laboratory biochemistry analyzer in patients in an emergency department (ED), Siriraj Hospital.

Material and Method

This prospective comparison was performed in an ED, Siriraj Hospital. A sample size of 53 was considered appropriate as this is the minimum sample size recommended for a method comparison study by Type I error is 0.01, power of the test is 90% and expectation of moderate relationship is 0.5[5]. Patients were selected based on their arterial blood gas and venous laboratory blood results. Both arterial and venous blood samples were obtained during ED evaluations.

The venous samples were collected with samples for other blood tests at the time of intravenous line insertion by needle or intravenous catheter and sent to a central laboratory biochemistry analyzer (Roche Modular ISE1800 Analyzer) in the hospital for analysis. It takes approximately 40 minutes for the results to be uploaded onto the hospital computer system. They can be obtained slightly more quickly via telephone.

The arterial samples, collected when the patients have an indication of arterial blood gas analysis, are directly taken into a heparinised syringe via a radial or brachial or femoral artery. The sample is immediately analyzed by the emergency departmental blood gas analyzer (Bayer 348). The entire process takes approximately 2-3 minutes before the results are available. Both arterial and venous samples were obtained before the initiation of treatment.

For venous samples, the recorded time was the time at which the blood samples were received by the laboratory as an emergency sample. For arterial samples, the taken time was the time at which the samples were analyzed by the arterial blood gas analyzer. These times were recorded automatically and checked to ensure that there was never more than 60 minutes between them.

The measurements for each patient were entered in a database for statistical analysis using the Statistical Package for Social Sciences (SPSS) 13.0 software (SPSS Inc., Chicago, IL) and compared using method for assessing the correlation between two methods of potassium measurement[6,7]. A p-value of less than 0.05 was considered significant.

Results

Sixty-five paired results of potassium from the laboratory biochemistry analyzer and the blood gas were obtained. Twelve paired results were excluded because there were different times between the laboratory biochemistry and the blood gas analyzer of more than sixty minutes. The remaining 53 paired results were compared. Baseline characteristics of the patients are shown in Table 1. The distribution of the potassium measurements, correlation and agreement between methods are presented in Fig. 1. The Intra-class Correlation Coefficient between each pair of two methods was 0.904 and 95% CI were 0.839 to 0.943, $p < 0.01$. The summary of the potassium level using laboratory biochemistry and blood gas analyzer is shown in Table 2. From 53 pairs result, 44 patients had

Table 1. Baseline characteristics of the subjects

Characteristic		Number (%)
Sex	Male	27 (50.9)
	Female	26 (49.1)
Age	< 15 years	0 (0)
	15-70 years	30 (56.6)
	> 70 years	23 (43.4)
Indication for venous blood sample	Establish diagnosis	14 (26.4)
	Assess severity of illness	33 (62.3)
	Guide therapy and monitor treatment	6 (11.3)
Indication for ABG	Establish diagnosis	22 (41.5)
	Guide therapy in respiratory problem	20 (37.7)
	Guide therapy in non-respiratory problem	11 (20.8)

ABG: arterial blood gas

Table 2. Summary of potassium level using laboratory biochemistry and blood gas analyzer

	Mean (mmol/L)	SD	95%CI of mean	Minimum (mmol/L)	Maximum (mmol/L)
Venous K	3.95	1.01	3.67 to 4.23	1.30	7.90
Arterial K	3.46	0.92	3.20 to 3.71	1.31	7.55

venous potassium level more than arterial potassium. The mean of difference between the two methods was 0.49 mmol/L. The authors analyzed the results further to better assess the agreement by Bland Altman method. The authors calculated these limits and these are shown as Fig. 2, which plots the mean between each arterial and venous potassium measurements against the difference.

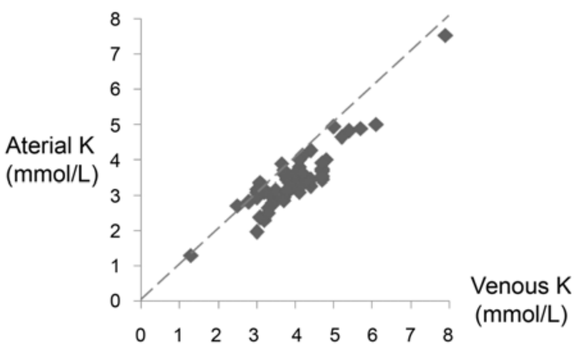

Fig. 1 Correlation of venous potassium from laboratory biochemistry analyzer and arterial potassium from blood gas analyzer measurements with the line of equality

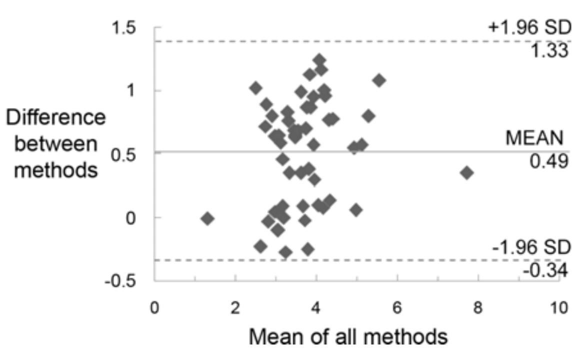

Fig. 2 Difference against mean for each arterial and venous potassium measurement. The mean difference ± 1.96SD is shown by dotted lines

Discussion

There are many controversial demonstrations in correlation between venous potassium from a laboratory biochemistry analyzer and arterial potassium from a blood gas analyzer. Previous research from the ICU setting has suggested that there was sufficient agreement between venous and plasma electrolyte measurements for arterial blood analysis to be substituted for venous measurements[8]. On the other hand, in Australia, potassium concentration derived from blood gas analysis may not be an acceptable substitute for venous potassium concentration in patients with diabetic ketoacidosis[9]. In cardiac arrest patients, the mean difference between arterial and venous potassium measurement is low at 0.106 mmol/L, but the 95% CI of the mean difference is too wide to be safe to use in clinical practice[10]. From a study in the United Kingdom, there was no significant difference between the means in ABG and arterial laboratory measurements but most clinicians still await laboratory confirmation of results obtained from blood gas analyzers[11].

The results indicated that venous potassium trends to be higher than arterial potassium about 0.49 mmol/L, while the studies of Jos□ and Johnston indicated a higher average of venous potassium than the average of arterial potassium about 0.03 mmol/L and 0.106 mmol/L respectively[10,11]. In the present study, the authors show that there is a significant agreement from the Intraclass Correlation Coefficient between each pair of potassium in two methods. The 95% CI of agreement were 0.893 to 0.943, which are contrary to previous reports of Johnston and King that identified wide limits of agreement[10,12].

Limitations of the present study are the difference of times when patients were selected to draw blood; they are on the basis of both their arterial blood gas and venous laboratory blood results being required, so they might not be the same time. There always was a gap between them that ranged between one minute and fifty-four minutes. Besides that, the two samples are also taken in different ways from different regions of blood circulation and this may give rise to further discrepancies. The different analyzers for the arterial and venous samples and accuracy of all laboratory equipment and devices are other factors that may influence some of the differences between the analyzers themselves. However, all equipment is supported and maintained by regular calibration and quality control procedures according to the manufacturers' instructions. As the result of the present study shows, there is sufficient agreement between potassium concentration measured by arterial blood gas analysis and that measured by venous analysis. Clinicians can use potassium levels obtained from a blood gas analyzer that are useful, valid, and more rapidly available than results from formal laboratory analysis. However, the authors advise caution be exercised in the analysis and be considered along with signs and symptoms of the patients.

References

1. The Resuscitation Council (UK). Advanced life support course provider manual. 3rd ed. London: Resuscitation Council (UK); 1998.
2. Harris JE. Influence of the metabolism of human erythrocytes on their potassium content. J Biol Chem 1941; 141: 579-95.
3. Sheppard CW, Martin WR, Beyl G. Cation exchange between cells and plasma of mammalian blood. II. Sodium and potassium exchange in sheep, dog, cow and man and effect of varying plasma potassium concentration. J Gen Physiol 1951; 34: 411-29.
4. Fox CL Jr, Baer H. Redistribution of potassium, sodium and water in burns and trauma, and its relation to the phenomena of shock. Am J Physiol 1947; 151: 155-167.
5. nQuery Advisor. Version 3.0: User's Guide. Los Angeles: Informer Technologies; 1999.
6. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986; 1: 307-10.
7. Bland JM, Altman DG. Statistical methods for assessing agreement between measurement. Biochimica Clinica 1987; 11: 399-404.
8. Shapiro BA, Cane RD, Kavanagh J. The reliability of electrolyte measurements in plasma. Intensive Care Med 1983; 9: 83-5.
9. Fu P, Douros G, Kelly AM. Does potassium concentration measured on blood gas analysis agree with serum potassium in patients with diabetic ketoacidosis? Emerg Med Australas 2004; 16: 280-3.
10. Johnson H, Murphy R. Agreement between an arterial blood gas analyser and venous blood analyser in the measurement of potassium in patients in cardiac arrest. EmergMed J 2005; 22: 269-71.
11. Jos□ RJ, Preller J. Near-patient testing of potassium levels using arterial blood gas analysers: can we trust these results? Emerg Med J 2008; 25: 510-13.
12. King R, Campbell A. Performance of the Radiometer OSM3 and ABL505 blood gas analysers for determination of sodium, potassium and haemoglobin concentrations. Anaesthesia 2000; 55: 65-9.

การหาความสอดคล้องระหว่างค่าโปแตสเซียมในเลือด ที่ได้จากการตรวจวิเคราะห์ก๊าซเลือดแดงและการตรวจจากเลือดดำ

มิ่งขวัญ วงษ์ยิ่งสิน, เสาวณีย์ สุขสุริยะโยธิน

ภูมิหลัง: *ภาวะโปแตสเซียมในเลือดผิดปกติอย่างรุนแรงสามารถเป็นอันตรายถึงชีวิต ดังนั้นการวินิจฉัยอย่างรวดเร็วจึงมีความสำคัญมาก ปัจจุบันการตรวจค่าโปแตสเซียมในเลือดใช้การตรวจจากเลือดดำ ซึ่งใช้เวลาในการรายงานผลค่อนข้างมาก ทำให้การรักษาผู้ป่วยล่าช้าโดยเฉพาะในผู้ป่วยภาวะวิกฤตที่ต้องการการรักษาอย่างเร่งด่วน การวิเคราะห์ระดับโปแตสเซียมจากการวิเคราะห์ก๊าซในเลือดแดงจึงเป็นอีกทางเลือกหนึ่ง ซึ่งสามารถทำได้รวดเร็วกว่า*

วัตถุประสงค์: *เพื่อหาความสอดคล้องระหว่างค่าโปแตสเซียมที่ตรวจวิเคราะห์ได้จากเลือดดำ และเลือดแดงในผู้ป่วยห้องฉุกเฉินโรงพยาบาลศิริราช*

วัสดุและวิธีการ: *การศึกษาแบบ cross sectional study ในผู้ป่วย 53 คน ที่ได้รับการเจาะเลือดตรวจหาระดับโปแตสเซียมในเลือดดำและเลือดแดงที่ห้องฉุกเฉินโรงพยาบาลศิริราช*

ผลการศึกษา: *ค่าเฉลี่ยของระดับโปแตสเซียมในเลือดดำ เลือดแดง และความแตกต่างของระดับโปแตสเซียมที่ได้จากการตรวจเลือดดำและเลือดแดง คือ 3.95, 3.46 และ 0.49 mmol/L ตามลำดับ ค่า Intraclass Correlation Coefficient และ ค่า 95% CI เท่ากับ 0.904 และ 0.839 ถึง 0.943,* $p < 0.01$

สรุป: *จากการศึกษาพบว่ามีความสอดคล้องกันระหว่างระดับโปแตสเซียมที่ตรวจได้จากเลือดดำและเลือดแดง แพทย์ผู้ดูแลผู้ป่วยสามารถใช้ค่าโปแตสเซียมที่ตรวจได้จากการวิเคาระห์ก๊าซในเลือดแดงเป็นแนวทางในการให้การรักษาผู้ป่วยเช่นเดียวกับการตรวจโปแตสเซียมจากเลือดดำได้*