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

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

<table>
<thead>
<tr>
<th></th>
<th>Mean (mmol/L)</th>
<th>SD</th>
<th>95%CI of mean</th>
<th>Minimum (mmol/L)</th>
<th>Maximum (mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venous K</td>
<td>3.95</td>
<td>1.01</td>
<td>3.67 to 4.23</td>
<td>1.30</td>
<td>7.90</td>
</tr>
<tr>
<td>Arterial K</td>
<td>3.46</td>
<td>0.92</td>
<td>3.20 to 3.71</td>
<td>1.31</td>
<td>7.55</td>
</tr>
</tbody>
</table>

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 in Fig. 2, which plots the mean between each arterial and venous potassium measurements against the difference.

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
การหาความสอดคล้องระหว่างค่าโปแตสเซียมในเลือดที่ได้จากการตรวจวิเคราะห์ก๊าซเลือดแดง และการตรวจจากเลือดดำ

มิ่งขวัญ วงศ์ยิ่งสิน, เสาวณีย์ สุขสุริยะโยธิน

ภูมิหลัง: ภาวะโปแตสเซียมในเลือดผิดปกติอย่างรุนแรงสามารถเป็นอันตรายถึงชีวิต ดังนั้นการวินิจฉัยอย่างรวดเร็วจึงมีความสำคัญมาก ปัจจุบันการตรวจค่าโปแตสเซียมในเลือดจากการตรวจจากเลือดดำ ซึ่งใช้เวลาในการรายงานผลดีขึ้นมาก ทำให้การรักษาผู้ป่วยทำได้เฉพาะในผู้ป่วยอาการก้าวหน้าของอาการวิกฤติ การวิเคราะห์ระดับโปแตสเซียมจากการตรวจก๊าซในเลือดแดงจึงเป็นอีกทางเลือกหนึ่ง ซึ่งสามารถทำได้รวดเร็วกว่า วัตถุประสงค์: เพื่อหาความสอดคล้องระหว่างค่าโปแตสเซียมที่ตรวจในห้องฉุกเฉินโรงพยาบาลศิริราช

วัตถุประสงค์: การศึกษาแบบ cross sectional study ในผู้ป่วย 53 คน ที่ได้รับการเจาะเลือดตรวจระดับโปแตสเซียมในเลือดดำและเลือดแดงที่ห้องฉุกเฉินโรงพยาบาลศิริราช

ผลการศึกษา: ค่าเฉลี่ยของระดับโปแตสเซียมในเลือดดำ เลือดแดง และความแตกต่างของระดับโปแตสเซียมที่ได้จาก การตรวจเพื่อด่าและเลือดแดง 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 แพทย์ผู้ดูแลผู้ป่วยสามารถใช้ค่าโปแตสเซียมที่ตรวจได้จากการวิเคราะห์ก๊าซในเลือดแดงเป็นแนวทางในการให้การรักษาผู้ป่วยที่เกี่ยวกับการตรวจโปแตสเซียมจากเลือดดำได้