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Are your hands clean enough for point-of-care electrolyte analysis?

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Summary

Aim: To investigate clinically significant analytical interference in point-of-care electrolyte analysis caused by contamination of blood specimens with hand disinfectant.

Methods: Six different hand hygiene products were added separately to heparinised blood samples in varying amounts as contaminant. The contaminated samples were analysed by three different blood gas and electrolyte analysers for assessing interference on measured whole blood sodium and potassium concentrations.

Results: There were significant analytical interferences caused by hand hygiene product contamination that varied depending on the combination of disinfectant and analyser. Small amounts of Microshield Antibacterial Hand Gel contamination caused large increases in measured sodium concentration. Such effect was much greater compared with the other five products tested, and started to occur at much lower levels of contamination. There was a trend towards lower sodium results in blood samples contaminated with Hexol Antiseptic Lotion (Hexol), the hand hygiene product that we used initially. Apart from AiE Hand Sanitizer, all the other hand disinfectants, especially Hexol, significantly elevated the measured potassium concentration, particularly when a direct ion-selective electrode method was used for measurement.

Conclusions: Hand disinfectant products can significantly interfere with blood electrolyte analysis. Proper precautions must be taken against contamination since the resultant errors can adversely affect the clinical management of patients.

Key words: Point-of-care (POC), blood gas analyser, alcoholic hand disinfectant, infection control, interference, ion-selective electrode.

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INTRODUCTION

The availability of point-of-care (POC) blood gas and electrolyte analysis has assisted clinicians in managing acutely ill patients. It enables a rapid turnaround time for obtaining test results. This is often critically important to the neonatologist or intensivist who is managing unstable patients such as those on assisted ventilation or intravenous fluid therapy that require close monitoring and therapeutic adjustments.

After the outbreak of severe acute respiratory syndrome (SARS) in Hong Kong in March 2003,[1–3] we observed abnormally high whole blood sodium concentrations (>150 mmol/L) collected in heparinised syringes from a Rapidpoint 400 analyser (RP400; Bayer Healthcare, USA) for POC blood gas and electrolyte analysis located in our neonatal unit. These abnormal test results did not correlate with the clinical condition of the corresponding patients. Upon cross checking, the sodium concentrations of these patients were found to be normal when venous blood samples were analysed in our main chemical pathology laboratory, where electrolytes are measured in heparinised plasma by the DP Modular analyser (Roche Diagnostics, USA) using an indirect ion-selective electrode (ISE) method. A malfunction of the RP400 analyser was suspected initially. However, quality control records showed no evidence of instrument failure. All POC blood gas and electrolyte analysers in our hospital are networked and connected centrally to the main chemical pathology laboratory, with automatic daily monitoring of performance (internal quality control) and subscription to the monthly external quality assurance program (QAP) organised by the Royal College of Pathologists of Australasia (RCPA) and the Australasian Association of Clinical Biochemists (AACB). This POC connectivity system has been accredited by the National Association of Testing Authorities, Australia (NATA) and RCPA. Table 1 illustrates some of the abnormal results.

Although strict infection control had already been implemented in our neonatal unit, the SARS outbreak necessitated further upgrade measures.[4] Our hand hygiene protocol was introduced in 1996.[5] This protocol was considered adequate even during the SARS epidemic, and was used in combination with other upgraded infection control procedures.[4] Part of the protocol required that health care workers disinfect both gloved hands by rubbing with an alcohol-based antiseptic agent before any kind of direct patient contact, including blood-sampling procedures such as heel-prick, venepuncture, and direct withdrawal of arterial blood via an *in situ* arterial catheter. During the SARS epidemic there was an inadequate supply of our usual hand hygiene product Hexol Antiseptic Lotion (Hexol; Sigma Pharmaceuticals, Australia) due to simultaneous upgrading of infection control measures in many other departments of nearly all hospitals in Hong Kong. Microshield Antimicrobial Hand Gel (MAH gel; Johnson & Johnson Medical, Australia) and some other products were provided as substitute (Table 2). The abnormal and discrepant sodium results began to emerge after we changed to MAH gel. Furthermore, the erroneous results

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TABLE 1 Examples of abnormal electrolyte results

Specimen type		Capillary whole blood (mmol/L)	Heparinised venous plasma (mmol/L)
Patient A	Sodium	179	140
	Potassium	4.8	4.7
Patient B	Sodium	164	137
	Potassium	6.4	4.7
Patient C	Sodium	187	133
	Potassium	5.1	4.6

Electrolytes in capillary whole blood specimens were analysed by the point-of-care Rapidpoint 400 analyser using direct ion-selective electrodes (ISE); heparinised venous plasma specimens were taken within 10 min of the capillary samples and analysed in the main chemical pathology laboratory by the DP Modular analyser using indirect ISE.

were noted to occur much more frequently with capillary blood sampling. Therefore, contamination of blood samples by MAH gel was suspected to be the cause of the spuriously high sodium results.

This study was initiated to investigate the analytical interference of POC electrolyte analysis caused by contamination of blood specimens with hand hygiene products, producing clinically significant errors that can adversely affect patient care.

MATERIALS AND METHODS

Six disinfectants that were commonly used in hospitals in Hong Kong (Table 2) were analysed for sodium and potassium concentrations in the main chemical pathology laboratory using inductively coupled plasma mass spectrometry (ICP-MS; Agilent 7500c mass spectrometer; Yokogawa Analytical Systems, Japan).

Two capillary tubes were prepared for further investigation of analytical interference. The first tube was filled with normal saline, while the second tube contained normal saline contaminated with a small drop of MAH gel. Both tubes were analysed by our POC RP400 analyser.

Three different POC blood gas and electrolyte analysers were included in this study. At our hospital, the Rapidpoint 400 and Rapidlab 865 analysers (RP400, RL865; Bayer Healthcare) are used at POC sites and the main chemical pathology laboratory, respectively. The i-STAT 1 analyser (i-STAT; Abbott Diagnostics, USA) is used at POC sites in other hospitals in Hong Kong. Both the RP400 and RL865 analysers use direct ion-selective electrode (ISE) technology to measure whole blood sodium and potassium concentrations, while the i-STAT employs a biosensor technology.

Six different hand disinfectant products (Table 2) were tested for interference of electrolyte analysis. The test samples were prepared by mixing 500 μL of heparinised whole blood with varying amounts of each hand disinfectant (0, 5, 10, 15, 20, 25 μL), except for MAH gel, where 1000 μL of heparinised whole blood was used with the same varying amounts of gel. The reason for this was because all three analysers produced substantially greater errors with MAH gel. The sodium and potassium concentrations of each contaminated sample were measured in duplicate and mean values were used for statistical analysis. The coefficients of variation (CV) of the measurements were within the previously established precision limits of the analysers. Student's t test was applied for assessing any significant difference between various measurements and analysers. A p value <0.05 was considered to be statistically significant. All probabilities were two tailed.

RESULTS

The measured sodium concentration of the saline-filled capillary tube was 146 mmol/L, and that of the MAH gel contaminated tube was >180 mmol/L. On the other hand, the sodium concentrations of all six disinfectants were found to be <5 mmol/L, while their potassium concentrations were <0.5 mmol/L using ICP-MS. These findings showed that MAH gel significantly interfered with sodium analysis on the RP400 analyser.

Figures 1 and 2 show that contamination of blood specimens with any of the six hand disinfectants can interfere with sodium and potassium analyses on all three POC analysers.

MAH gel contamination at concentrations $\geq$1% (10 μL per 1000 μL whole blood) caused marked increases in measured sodium concentration on the RP400 analyser. The RL865 and i-STAT analysers were also affected, but to a much lesser extent. For potassium analysis, all three analysers had similar interference showing progressive

TABLE 2 The six hand disinfectant products used in Hong Kong hospitals during the SARS epidemic

Brand (Supplier)	Active ingredients	Other constituents
Microshield Antibacterial Hand Gel (Johnson & Johnson Medical Pty Ltd, North Ryde, NSW, Australia)	Ethanol 61.5%	Methyl hydroxybenzoate 0.011% Propyl hydroxybenzoate 0.003% Diazolidinyl urea 0.125% Benzalkonium chloride 0.1% Iodopropynyl butylcarbamate 0.001% Phenoxyethanol 0.5%
Microshield Handrub (Johnson & Johnson Medical Pty Ltd, North Ryde, NSW, Australia)	Ethanol 70% Chlorhexidine gluconate 0.5%	'Emollient' 'Moisturiser'
Hexol Antiseptic Lotion (Sigma Pharmaceuticals Pty Ltd, Clayton, Vic, Australia)	(per 100 mL): Ethanol 26.5 mL Chlorhexidine gluconate 1 g Isopropyl alcohol 42 mL	'Skin conditioners
Swashes Handrub – Topical Antiseptic Lotion (Swashes Chemical Co Ltd, Shenzhen, People's Republic of China)	Ethanol Chlorhexidine	'Emollient' 'Moisturiser'
Avagard Antiseptic Handrub (3M Pharmaceuticals Pty Ltd, Thornleigh, NSW, Australia)	Ethanol 58% Chlorhexidine gluconate 0.5%	Not listed
AiE Hand Sanitizer (DeVos Cosmetics Asia Ltd, Hong Kong, People's Republic of China)	Ethanol 70%	Water Glycerin Carbomer Fragrance Aloe vera Glycol