Effect of Hemolysis on Routine Blood Gas and Whole Blood Analytes

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ABSTRACT

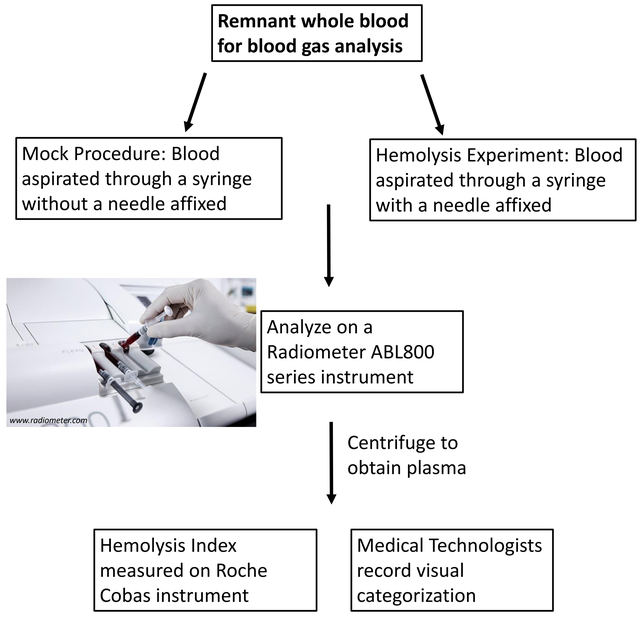
Background: Hemolysis is a major pre-analytical concern for many laboratory analytes, however instruments utilized for whole blood chemistries and blood gas measurements lack the ability to detect and measure the degree of hemolysis. This study evaluated the effect of hemolysis on 13 routine whole blood and blood gas analytes and compared visual assessments of hemolysis to measured hemolysis (H-index).

Methods: Remnant whole blood samples (n=85) were split into two portions and aspirated through a syringe one or more times. To induce hemolysis, a needle was affixed to the end of the syringe to provide shear stress, and a mock procedure without syringe was used as a control. Samples were analyzed on a Radiometer ABL800 series instrument, centrifuged, and the H-index of the plasma portion was measured. Two medical technologists recorded a visual categorization of the specimens as slightly, moderately, or severely hemolyzed.

Results: Hemolysis had a modest effect on metabolites and most cooximetry components, with percent bias within ±5% at all levels of hemolysis. Methemoglobin exhibited a larger overall negative bias, up to 13.3%. The absolute pH bias was fairly consistent (within 0.1 pH units) across all levels of hemolysis. As expected, potassium displayed a significant positive bias with increasing hemolysis. Sodium and ionized calcium displayed overall linear trends with a significant negative bias.

Conclusions: Hemolysis can falsely increase or decrease a range of blood gas analytes and lead to misinterpretation of results and adversely affect clinical decision-making. Therefore, equipping current blood gas analyzers with hemolysis detection capabilities is crucial to enable laboratories to mitigate this effect and ensure accurate results for patient care.

EXPERIMENTAL WORKFLOW



RESULTS AND DISCUSSION

Table 1A – Comparison of percent difference at different levels of hemolysis. Percent difference is (hemolyzed–mock) / mock *100.

	Slight Hemolysis, n= 35		Moderate Hemolysis, n= 24		Severe Hemolysis, n= 27	
Analyte	**Mean ± SD**	**% Diff**	**Mean ± SD**	**% Diff**	**Mean ± SD**	**% Diff**
Sodium(mmol/L)	141.24 ± 4.35	-0.56	138.88 ± 4.31	-1.10	134.78 ± 6.38	-3.96
Potassium(mmol/L)	3.98 ± 0.56	6.02	4.84 ± 0.73	24.01	8.97 ± 2.73	108
Chloride(mmol/L)	109.00 ± 5.03	0.63	109.08 ± 4.70	0.73	105.90 ± 5.97	-0.69
Calcium(mmol/L)	1.08 ± 0.08	-2.99	1.03 ± 0.08	-5.65	0.91 ± 0.13	-15.53
Glucose(mg/dL)	125.83 ± 47.65	-2.69	140.17± 50.63	-0.80	141.92 ± 66.5	-1.73
Creatinine(mg/dL)	1.12 ± 0.64	1.95	1.21 ± 0.64	1.51	2.41 ± 2.73	1.47
Lactate(mmol/L)	2.31 ± 0.87	1.38	2.03± 0.91	-0.61	2.75 ± 1.41	-0.93
Hemoglobin(g/dL)	10.16 ± 2.95	0.69	10.42 ± 2.68	1.17	10.03 ± 2.08	1.40
Oxyhemoglobin(%)	95.67 ± 1.44	0.34	95.45± 1.69	0.73	96.24 ± 0.98	0.37
Carboxyhemoglobin(%)	2.98 ± 1.07	2.28	2.78 ± 1.08	4.87	2.58 ± 0.83	1.13
Methemoglobin(%)	0.95 ± 0.27	-6.61	0.86 ± 0.35	-12.29	0.90 ± 0.44	-13.28
Oxygen Saturation (%)	99.48 ± 1.29	0.27	99.01 ± 2.04	0.68	99.68 ± 0.37	0.25
pH	7.57 ± 0.10	1.26	7.54 ± 0.08	1.05	7.53 ± 0.12	0.69

Degree of hemolysis was categorized by the delta (hemolyzed - mock) of the measured H-index: slight hemolysis was defined as an H-index delta of <100, moderate as 100-500 and severe as >500.

Table 1B – Correlation analysis of hemolysis classification based on delta H- Index vs visual classification.

		H-Index Classification of Hemolysis		
		Slight	**Moderate**	**Severe**
Visual Observation	**Slight**	33	2	0
	Moderate	1	21	2
	Severe	0	2	24

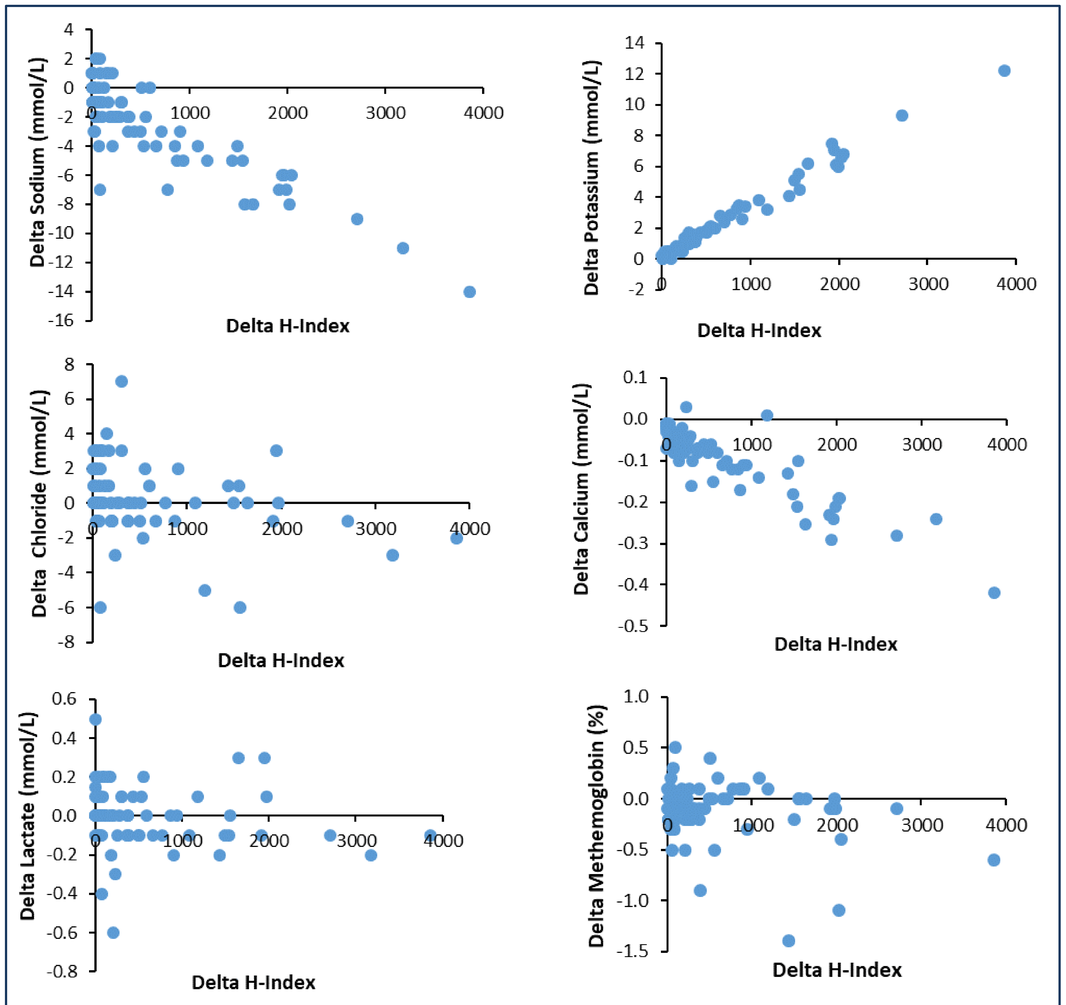


Figure 1 – Absolute analyte differences (hemolyzed–mock) plotted against H-index difference (hemolyzed–mock) for sodium, potassium, chloride, ionized calcium, lactate and methemoglobin.

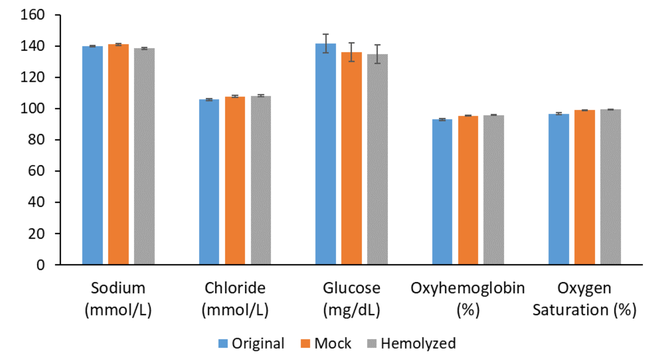


Figure 2 – Bar chart of mean values of analytes for original, mock-treated and hemolyzed specimens. Error bars represent standard errors of the mean values.

Bias due to hemolysis can occur through several mechanisms. Predominant intracellular analytes, such as potassium, are falsely elevated due to their release from red blood cells (RBCs). Conversely, predominant extracellular analytes, such as sodium, chloride and glucose are falsely decreased due to dilutional effect. Creatinine, lactate and glucose were minimally affected by hemolysis, while ionized calcium demonstrated a negative bias. The absolute pH bias was fairly consistent across all levels of hemolysis, close to 0.1 pH units. Methemoglobin exhibited a negative bias and may have significant implications in the treatment of methemoglobinemia. This analysis also demonstrated a high level of concordance between the visual classification and instrument measured hemolysis, but this observation may be influenced by training and skill of testing personnel.

CONCLUSION

The results of this study emphasize the necessity for evidence-based quality guidelines in blood gas analysis, encompassing a broader range of analytes. Additionally, there is a need for the development of instrumentation capable of detecting spectrometric interferents in whole blood samples, including the establishment of hemolysis thresholds for blood gas analytes. This data set can be utilized to generate clinical thresholds for future instrumentation which allows for hemolysis measurement.

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