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Original Research

Evaluation of a Portable Analyzer for Determining Hemoglobin Concentrations and Oxygen Saturation in Whole-Blood Samples From Domestic Animals

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ABSTRACT

Accuracy and precision of a prototype point-of-care (POC) hemoglobin (Hb) and oxygen saturation (SO_2) analyzer were compared to a benchtop analyzer, as well as the use of the prototype in a field setting. Arterial and venous Hb concentrations ([Hb]) and SO_2 were determined from 180 whole-blood samples from dogs, cats, and horses. Hemoglobin concentrations and SO_2 values were consistently lower ($P < .0001$) for the prototype compared to the benchtop analyzer. Deming's regression and Bland–Altman bias representation with concordance analysis revealed good accuracy and precision but poor concordance. When separated out by species, concordance was moderate to excellent for canine but poor for equine samples; accuracy and precision were unchanged. When separated by sample type, there was loss of accuracy and precision for equine arterial SO_2 and canine venous SO_2. Whole-blood jugular venous [Hb] and SO_2 values determined for 26 horses before and after exercise using the prototype analyzer in a wide range of temperatures revealed good consistency and precision. In conclusion, the prototype POC had good concordance with the benchtop analyzer for canine but not equine samples, with good accuracy and precision for equine and canine [Hb] and SO_2. Concordance results indicate the prototype's calibration settings may need to be adjusted for different species and sample type if using the comparative benchtop analyzer's reference values. Overall, the prototype POC analyzer had good accuracy and precision for the two analytes for both species and sample types, was simple and practical to use in the field, and may be a suitable substitute for a benchtop analyzer.

1. Introduction

Point-of-care (POC), portable clinical analyzers are primarily aimed at practicality, ease of use, and affordability while providing quality results comparable to gold-standard benchtop analyzers. Handheld analyzers are increasingly used in field-based settings including studies evaluating athletic species during exercise training and performance. Furthermore, in a veterinary hospital or ambulatory situation, handheld analyzers are often a realistic way to assess patients where electrical resources are unavailable, the patient cannot be easily transported, and/or a quick turn-around time of information is desirable especially when critical conditions of the patient require immediate treatment decisions to be made.

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It is recognized that rapid and accurate measurement of hemoglobin concentrations ([Hb]) and oxygen saturation (SO_2) can provide invaluable information regarding oxygen (O_2) availability for use in tissues. This type of information is vital for the monitoring of critical care patients, patients during anesthesia as well as for the evaluation of performance. Because 97% of O_2 is transported throughout the body bound to Hb, arterial blood O_2 content is determined principally by [Hb] (i.e., O_2-carrying capacity) as well as how much O_2 is actually bound to Hb (i.e., SO_2). Because one of the primary goals for managing critically ill patients, anesthetized patients, and exercising animals is the maintenance of O_2 delivery to tissues to meet metabolic demand, measurement of [Hb] and SO_2 can provide important pieces of information despite differing underlying issues.

Most systems used in hospital settings for measurement of [Hb] and SO_2 are expensive automatic benchtop analyzers that require calibrator gases and buffers as well as skilled personnel and thus are not practical for the majority of routine clinical veterinary practices. A convenient, accurate, and cost-effective means to measure [Hb] and SO_2 as a way to assess O_2 availability and delivery capability in a modern clinical veterinary practice is required. StableLab has produced a prototype POC analyzer (Epona Biotech, Sligo, Ireland). This is a light-weight, handheld portable battery-powered analyzer that uses disposable cartridges in which all blood remains inside, and the volume of blood required for analysis is small (approximately 10 μl). The cartridges are inexpensive, do not require special handling, and have no expiration date. The analyzer has an automatic self-calibration sequence that runs before each analysis with an analysis time of approximately 8 seconds.

This device calculates [Hb] and SO_2 by spectrophotometric means (i.e., whole-blood CO-oximetry, hemoximetry). The absorbance of the whole-blood sample is measured at multiple wavelengths with an algorithm used to calculate [Hb] based on the different wavelengths by which oxyhemoglobin (O_2Hb) and deoxyhemoglobin (HHb) are absorbed with a third wavelength measured as a reference [1]. The calculated quantity of O_2Hb and HHb is then combined to give the total [Hb], with the SO_2 derived by dividing the amount of O_2Hb by the total amount of Hb and multiplying by 100. Whole-blood spectrophotometry is considered to be the gold-standard method for measurement of O_2Hb saturation because all the different fractions of Hb are used in the calculation, giving what is referred to as the fractional O_2 saturation (fraction of Hb, i.e., oxygenated) [2].

This prototype has been previously validated against the ADVIA 120 hematology system (Siemens Ireland, Dublin, Ireland) for the determination of [Hb] (unpublished); the ADVIA 120 is a system which uses the gold-standard Drabkin's (cyanmethemoglobin) method for [Hb] analysis [3]. From $n = 73$ resting equine venous whole-blood samples, the prototype analyzer showed good precision (Pearson's correlation factor of 0.98) and accuracy (bias correction factor of 0.99) for [Hb] determination, with a concordance correlation coefficient of 0.98 (95% confidence interval [CI]: 0.96–0.98) indicating substantial agreement between the two analyzers.

The first aim of the study was to examine the accuracy and precision of the StableLab prototype POC analyzer for calculation of venous and arterial whole-blood [Hb] and SO_2 in domestic animals (cats, dogs, horses) against a benchtop blood gas analyzer that also calculates [Hb] and SO_2 by spectrophotometric means. The second was to evaluate the use of the prototype analyzer in a field-based setting evaluating venous whole-blood from Thoroughbred (Tb) horses before and after intense exercise.

2. Materials and Methods

All studies were approved by University College Dublin Animal Research Ethics Committee with owner consent.

2.1. Study 1: Laboratory Evaluation of the Prototype POC Compared to a Benchtop Analyzer

2.1.1. Sample Population

Animals (dogs, cats, horses) admitted to the University Veterinary Teaching Hospital (UVTH) between July 2013 and January 2014 requiring blood gas analysis for clinical evaluation and treatment including anesthesia for routine and emergency surgical procedures were included into the study.

2.1.2. Experimental Protocol

Whole-blood venous and arterial samples were evaluated using both the StableLab prototype POC analyzer and an autocalibrated benchtop blood gas analyzer (Siemens Rapidlab 1260 series, Siemens Ireland, Dublin, Ireland). This whole-blood CO-oximetry benchtop analyzer undergoes an automatic quality control (AQC) run along with a full calibration run three times a day and a one part calibration run every hour. This is a cartridge-based system that allows a standardized quality control to occur at regular intervals. Depending on the reason for the blood gas analysis (i.e., monitoring of a patient during anesthesia), multiple blood samples from the same patient were often evaluated. For each blood gas sample measurement, 1 mL of venous or arterial blood was collected anaerobically into a heparinized disposable blood gas syringe (RAPIDLyte, Siemens Healthcare Diagnostics Inc, Tarrytown, NY) and analyzed immediately in duplicate and simultaneously for each analyzer. Blood was introduced into the benchtop analyzer first and then immediately into the prototype POC analyzer. For the benchtop analyzer, direct automatic pumping of blood (150 μl) from the 1-mL disposable syringe was used. For the prototype POC analyzer, a small volume of whole blood (10 μl) was dispensed from the same syringe into the cartridge sample chamber up to the full mark. Measurement was triggered by inserting the cartridge into the analyzer on which the results were displayed on the screen and stored in the analyzer's memory.

2.2. Study 2: Field Evaluation of the Prototype POC Analyzer

2.2.1. Sample Population

Twenty-six 2-year-old Tb racehorses (17 colts, 9 fillies, 24.2 ± 1.7 months) were evaluated before and after intense exercise on an all-weather gallop.