Evaluation of the Harleco Apparatus for Determining Carbon Dioxide in Whole Blood

Bill C. Strever, Carl A. Johnson, and Richard H. Gadsden

A simplified method for determining the total CO₂ content of whole blood is evaluated, and results are compared to those obtained with a "Blood Gas Analyzer" (Instrumentation Laboratories). A high degree of correlation is shown. The described method makes such determinations simple and reliable, especially for emergency use in the laboratory or at bedside.

Additional Keyphrases: Blood Gas Analyzer

In clinical emergencies it is often necessary to rapidly determine blood CO₂ content, so that the patient may be promptly treated.

The Harleco Co. has introduced an apparatus to determine CO₂ content of plasma and serum, based on principles of the classical Van Slyke volumetric method (1). We have used this apparatus to directly determine total CO₂ in whole blood, and compared results to those obtained by another commonly used laboratory method. The Harleco method can be performed by individuals with minimal training, and immediately after blood is drawn.

Materials and Methods

Apparatus and Reagents

A "Harleco CO₂ Apparatus Set" (Harleco, Philadelphia, Pa. 19143) was used for CO₂ content determinations on whole blood. Results from a Model 113 "Blood Gas Analyzer" (Instrumentation Laboratories Inc., Lexington, Mass. 02173) were compared.

Carbon dioxide-liberating reagent (22% lactic acid), sodium bicarbonate standard (30 mmol/liter), a pre-calibrated syringe (Figure 1), and reaction vessels with rubber caps and clamp are included in the kit.

Procedures

Blood samples were collected in syringes, with use of sodium heparin. The syringe was then purged of air and capped until analysis. pH and P₇CO₂ were measured by the reference method according to directions of the manufacturer. With a nomogram, the values were converted to total CO₂ content, in millimoles per liter (2).

A small reaction vessel containing either specimen or standard is capped with a one-hole cap. Lactic acid is drawn into the calibrated syringe and the tip is inserted into the hole in the cap; the three components are then clamped together. Lactic acid is added to the reaction vessel by depressing the syringe plunger. Mixing is accomplished by use of a vortex-type mixer. Liberated CO₂ forces the syringe plunger to move in the barrel and the volume change is read directly from the syringe marking. Syringe readings are converted to total CO₂ content of whole blood by comparison with the gas volume produced by a standard.

Results and Discussion

A minimum mixing time of 15 s was used, and the gas volume recorded. Mixing was continued and the gas volume recorded again after a total mixing time of 2 min. Two methods of dispensing whole blood into the reaction vessel were also tested. The results obtained when 1 ml of blood was dispensed directly from the collecting syringe and when blood was measured with a 1-ml volumetric pipet were as follows, when CO₂ (in millimoles per liter), 15 s mixing, was plotted on the abscissa vs. CO₂ (millimoles per liter), 2 min mixing, on the ordinate:

\[
\begin{array}{lll}
\text{Syringe} & \text{Pipet} \\
n & 45 & 25 \\
r & .861 & .917 \\
y & 8.92 + .91x & 7.56 + 1.01x \\
\end{array}
\]

Fig. 1. Assembled Harleco apparatus, showing syringe, rubber cap, reaction vessel, and clamp.

From the Departments of Biochemistry and Clinical Pathology, Medical University of South Carolina, Charleston, S. C. 29401.

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When CO₂ (in millimoles per liter), syringe dispensed, was plotted on the abscissa vs. CO₂ (in millimoles per liter), pipet dispensed on the ordinate, the results were:

\[
\begin{align*}
15 \text{ s} & \quad 2 \text{ min} \\
\text{n} & = 25 \quad \text{n} = 25 \\
r & = .968 \quad r = .891 \\
y & = 0.91 + 0.95x \quad y = 0.49 + 0.94x
\end{align*}
\]

n is the number of paired determinations, r is the correlation coefficient, and the equation of the least-squares regression line is \( y = a + bx \) (where \( a \) is the y-intercept, and \( b \) the slope). In this case both the regression line and correlation coefficient show that both methods of dispensing blood to the reaction vessel gave comparable results, and that differences in blood dispensing do not result in a consistent bias in total CO₂ content. The slopes of both lines are comparable, and approach unity; y-intercepts for both time periods approach the ordinate and the correlation coefficients are quite high. Therefore, we conclude that 1 ml of blood dispensed into the reaction vessel from the collecting syringe (either a 5-ml or 10-ml syringe) is as acceptable as measuring samples with a pipet.

In Figures 2 and 3, values obtained with the Harleco method by using syringe delivery of 1 ml of whole blood are compared with values obtained for the same specimen by the comparison method. Figure 2 shows a lower y-intercept than Figure 3, with comparable slopes, indicating that a greater gas volume is present after 2 min of mixing than after 15 s of mixing. Figures 2 and 3 show good correlation between results of the two methods.

Although either 15 s or 2 min of mixing is satisfactory for the determination with the Harleco apparatus, the greater y-intercept in Figure 3 indicates that a 15-s mixing gives values that better correspond to the normal range. The total CO₂ values obtained with the Harleco apparatus are not exactly equivalent to those obtained by the other method, but the results correlate well.

We found the apparatus easy to use, and virtually trouble free. Mixing the reaction vessel with the syringe attached requires practice. Shortly after 2 min of mixing, the entire specimen forms a coagulum. The time for the coagulation to occur was variable.

The procedure is entirely adequate as an emergency method. Speed of determination, reliability of total CO₂ content, and ease of performance make this a technique of value in many situations.

The Harleco apparatus used in this study was a gift of Dr. John A. O'Malley of Harleco Co.

**References**