Accuracy and Precision in Point-of-Care Lipid Testing: CardioChek® P•A Point-of-Care Test System and PTS Panels® Test Strips

Sponsored by
Arthur Roberts, MD of
The Living Heart Foundation

The Living Heart Foundation (LHF) is a nonprofit organization established to combat cardiovascular disease and provide risk stratification for cardiac, pulmonary, and metabolic conditions through onsite screening and integrated health programs. The LHF provides these services to groups that have traditionally been overlooked, especially high school, college, and professional athletes. The LHF continually looks for ways to support a proactive approach to maintaining cardiovascular health and identifying cardiovascular risk factors. Dr Roberts, an esteemed cardiologist and heart surgeon, founded the organization in 2001 after retiring from private practice.

Introduction

With the increasing incidence of heart disease and high cholesterol, Point-of-Care lipid testing systems, such as the CardioChek P•A analyzer from Polymer Technology Systems, Inc. (PTS), offer physicians a reliable and accurate method to provide immediate results, allowing face-to-face interaction with patients during their office visits.

Background on CardioChek® P•A System and PTS Panels® Test Strips

Polymer Technology Systems, Inc. manufactures the CardioChek P•A System and PTS Panels Test Strips. The CardioChek P•A is a hand-held, portable, Point-of-Care whole blood analyzer utilizing reflectance photometry. CardioChek P•A is used with PTS Panels Test Strips—disposable, single-use test strips formulated to analyze specific blood chemistries. Results are obtained in 1 to 2 minutes. The CardioChek P•A System is FDA 510(k) cleared, CLIA-waived, and CE labeled.

PTS Panels Test Strips offer a variety of single tests as well as several panel tests that combine two or three analytes on a single test strip. The method used to analyze a particular parameter is identical for the single tests and for the combination tests.

Background on the Cholesterol Reference Method Laboratory Network (CRMLN)

With guidance from the Centers for Disease Control and Prevention (CDC), the CRMLN was established to certify manufacturers of clinical diagnostic products that measure Total Cholesterol (TC), HDL Cholesterol (HDL-C), or LDL Cholesterol (LDL-C). Certification provides evidence of traceability to the National Reference System for Cholesterol (NRS/Chol).

The CRMLN issues guidelines regarding the performance of products used to analyze blood samples for specific lipid levels. The CRMLN uses reference methods that are rigorously standardized to the CDC reference methods to ensure uniformity of lipid measurements worldwide.

Criteria for CRMLN cholesterol certification

The CRMLN (part of the CDC) has established test protocols using accepted "gold standard" reference methods. In order to be CRMLN certified, results must meet the following criteria:

CRMLN cholesterol certification criteria

Parameter	Total Cholesterol	HDL Cholesterol	LDL Cholesterol
R^2	>0.975	>0.975	>0.975
Bias at medical decision points	≤3% at 200 mg/dL (5.18 mmol/L) ≤3% at 240 mg/dL (6.22 mmol/L)	≤5% at 40 mg/dL (1.04 mmol/L) ≤5% at 60 mg/dL (1.55 mmol/L)	≤4% at 100 mg/dL (2.59 mmol/L) ≤4% at 130 mg/dL (3.37 mmol/L) ≤4% at 160 mg/dL (4.14 mmol/L)
Average % bias	≤3%	≤5%	≤4%
Among-run CV	≤3%	≤4%	≤4%

NCEP guidelines for Total Error (TE)

The National Cholesterol Education Program (NCEP) of the National Institutes of Health (NIH) has established test protocols and guidelines for acceptable deviation from "truth" (defined as the National Reference System for Cholesterol [NRS/Chol] reference value).

These guidelines state that TE should be within the following limits from the reference value when these test protocols are followed:

	Total Cholesterol	HDL Cholesterol	LDL Cholesterol
Total Error	≤8.9%	≤13%	≤12%

NCEP-Adult Treatment Panel (ATP) III guidelines for cholesterol management

In addition to device certification guidelines, NCEP also publishes patient care guidelines and recommends a complete lipid profile for coronary heart disease risk assessment. Periodically NCEP updates its clinical guidelines for cholesterol testing and management. However, these current guidelines are not meant to replace the physician's clinical judgment; based on all the clinical and diagnostic information available, the physician must ultimately determine the appropriate treatment for each patient.

ATP III classification of LDL, TC, and HDL Cholesterol[1]

LDL Cholesterol—Primary target of therapy		
US Units	**SI Units**	
<100 mg/dL	<2.59 mmol/L	Optimal
100-129 mg/dL	2.59-3.35 mmol/L	Near optimal/above optimal
130-159 mg/dL	3.36-4.12 mmol/L	Borderline high
160-189 mg/dL	4.13-4.91 mmol/L	High
≥190 mg/dL	≥4.92 mmol/L	Very high
Total Cholesterol		
<200 mg/dL	<5.18 mmol/L	Desirable
200-239 mg/dL	5.18-6.20 mmol/L	Borderline high
≥240 mg/dL	≥6.21 mmol/L	High
HDL Cholesterol		
<40 mg/dL	<1.04 mmol/L	Low
≥60 mg/dL	≥1.55 mmol/L	High

Performance Data Summary

Protocol

- Whole blood and serum samples were collected at the same time from 41 subjects.
- Anticoagulated EDTA whole blood was tested in duplicate for Total Cholesterol on a CardioChek P•A brand analyzer using PTS Panels Test Strips.
- Controls were tested daily for twenty days using a CardioChek P•A brand analyzer and PTS Panels Test Strips.
- Serum was sent to a CRMLN laboratory where the serum was tested in duplicate by the Abell-Kendall beta-quantification method which entails:
  - Centrifuging the serum in a refrigerated high-speed centrifuge (ultracentrifuge) for approximately twenty four hours.
  - Removing and assaying by the Abell-Kendall method.
- Twenty sets of paired results selected at the discretion of the CRMLN laboratory were used to perform the correlation analysis, which established the coefficient of determination (R^2)* and bias across the linear range of the assay. (Forty sets of paired results are evaluated for HDL and LDL.)
- The among-run coefficient of variation (CV)* was calculated from the 20 controls.
- Total Error (TE)* was calculated as: TE = Average % bias + (1.96 x among-run % CV).

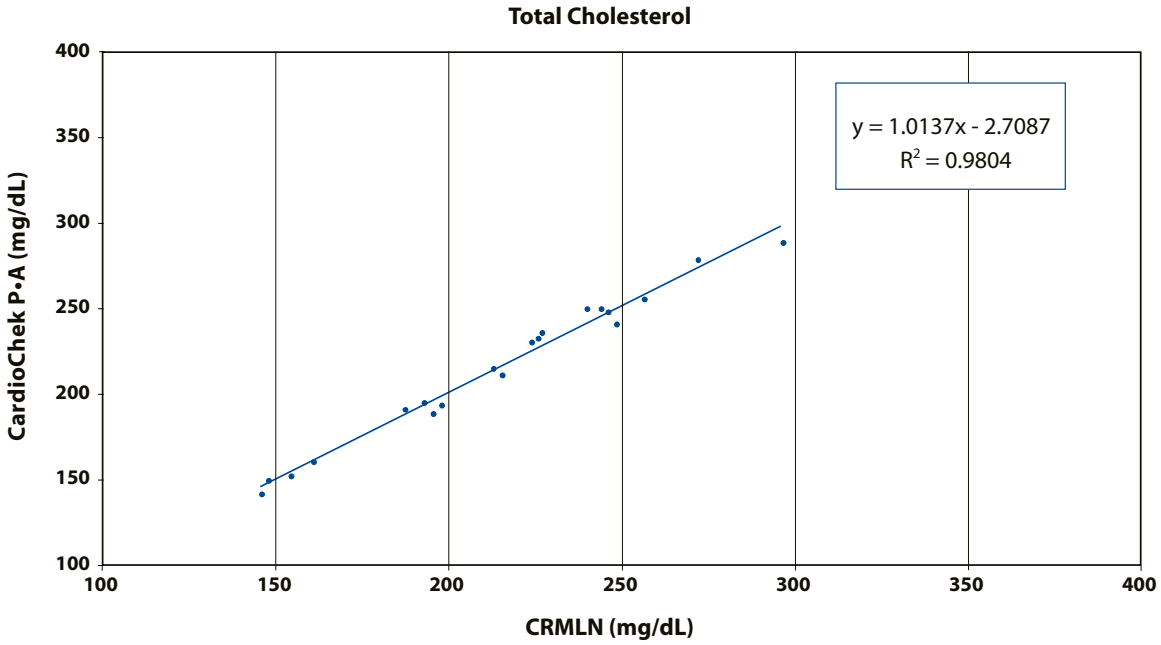
* *See page 10 for a definition of terms.*

Total Cholesterol

CRMLN certified that the CardioChek P•A System met the required levels for accuracy and precision individually and the combined measure of Total Error as defined by the NCEP for Total Cholesterol.

CardioChek P•A System CRMLN Total Cholesterol results

Parameter	Total Cholesterol	Certification Criteria	Meets
R^2	0.9804	>0.975	√
Bias at medical decision points	0.0% at 200 mg/dL (5.18 mmol/L) 0.6% at 240 mg/dL (6.22 mmol/L)	≤3% at 200 mg/dL (5.18 mmol/L) ≤3% at 240 mg/dL (6.22 mmol/L)	√
Average % bias	0.0%	≤3%	√
Among-run CV	2.3%	≤3%	√
Total error	4.7%	≤8.9%	√

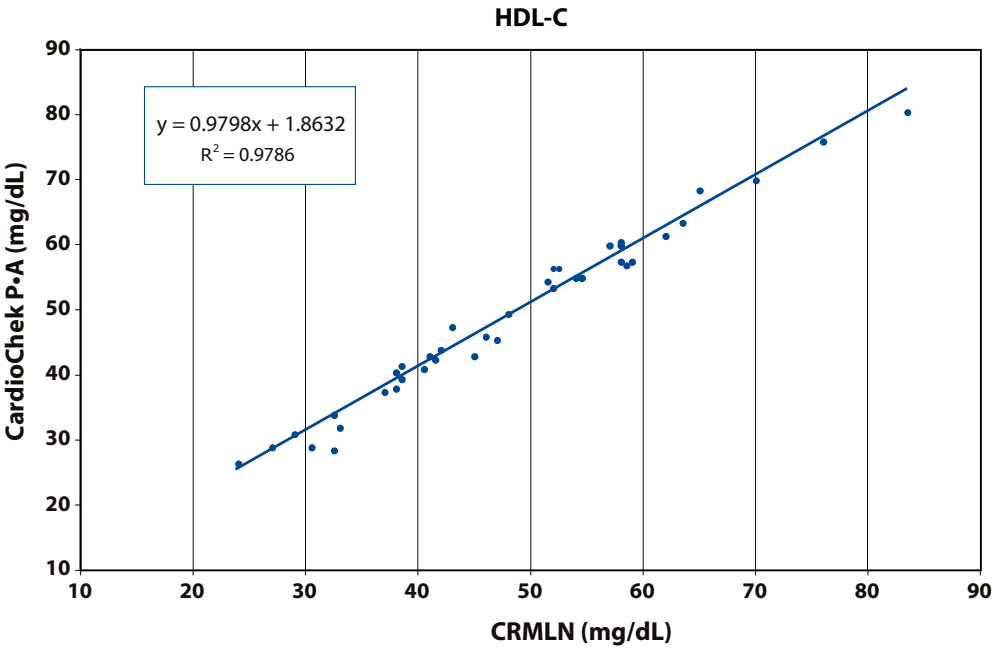


HDL Cholesterol

CRMLN certified that the CardioChek P•A System met the required levels for accuracy and precision individually and the combined measure of Total Error (TE) as defined by the NCEP for HDL Cholesterol.

CardioChek P•A System CRMLN HDL Cholesterol results

Parameter	HDL Cholesterol	Certification Criteria	Meets
R^2	0.9786	>0.975	√
Bias at medical decision points	2.6% at 40 mg/dL (1.04 mmol/L) 1.1% at 60 mg/dL (1.55 mmol/L)	≤5% at 40 mg/dL (1.04 mmol/L) ≤5% at 60 mg/dL (1.55 mmol/L)	√
Average % bias	2.1%	≤5%	√
Among-run CV	1.9%	≤4%	√
Total error	5.9%	≤12%	√



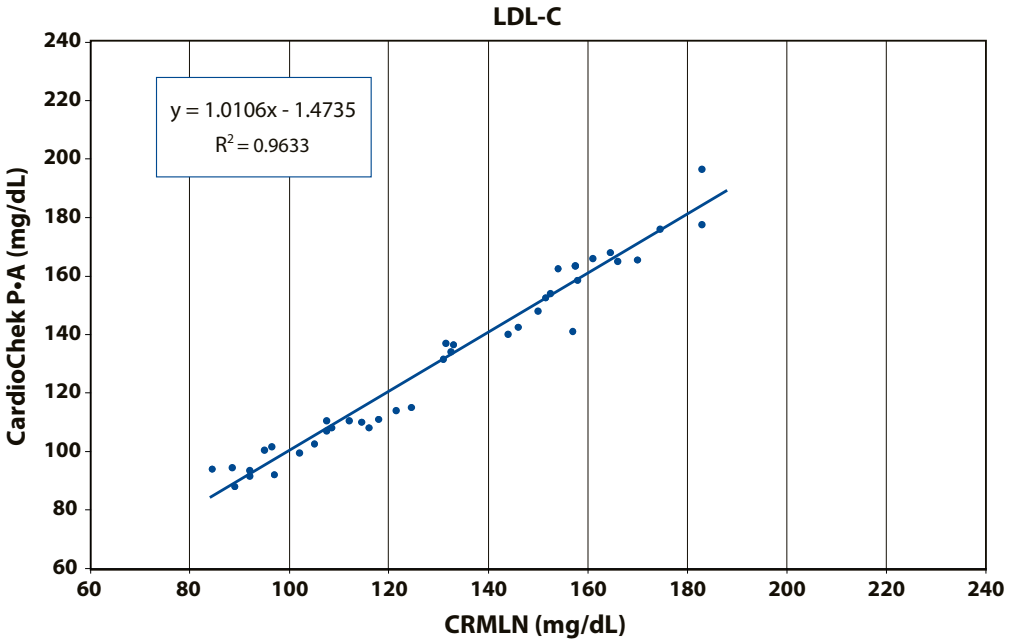
LDL Cholesterol

The CardioChek P•A System exhibited excellent performance compared to CRMLN.

CardioChek P•A System CRMLN LDL-Cholesterol results

Parameter	LDL Cholesterol
R^2	0.9633
Bias at medical decision points	-0.4% at 100 mg/dL (2.59 mmol/L) -0.1% at 130 mg/dL (3.37 mmol/L) 0.1% at 160 mg/dL (4.14 mmol/L)
Average % bias	-0.1%
Among-run CV	2.6%
Total Error	5.3%

Triglycerides



The CRMLN does not offer certification for triglycerides. However, the CardioChek P•A System was tested for accuracy in a clinical evaluation performed at three sites (111 persons) comparing CardioChek P•A to results from an automated method run at a CRMLN laboratory.

Triglycerides accuracy results

Parameter	Triglycerides
R^2	0.97

Total precision was measured at the decision-making cutpoints for triglycerides, of 200 mg/dL (2.26 mmol/L) and 400 mg/dL (4.52 mmol/L).

Triglycerides precision results

Parameter	Triglycerides
CV at decision-making cutpoints	2.06% at 200 mg/dL (2.26 mmol/L) 4.17% at 400 mg/dL (4.52 mmol/L)
Within-run CV	Mean 4.3%

NOTE: Many factors may contribute to variability in measured results; however, CRMLN certification ensures that, despite inherent testing error, at least 95% of all the results will fall within an acceptable range.

Why certify products for accuracy—what makes accuracy and precision so necessary?

Accuracy and precision are extremely important in the field of science; without them there would be no way to determine if what is being measured is true. Accuracy refers to the degree of conformity of a measured or calculated quantity to an actual (true) value.

Precision, on the other hand, is the degree to which future measurements or calculations yield the same or similar results. Accuracy is closely related to precision, but it's not the same thing. A result is said to be valid when it is both accurate *and* precise.

Let's look at a common analogy to illustrate the difference betwen accuracy and precision.

Figure 1. High accuracy with high precision

When results have both a high degree of accuracy and precision they will be clustered together around the target area (true value).

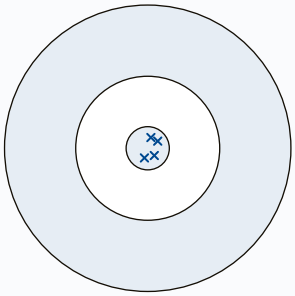


Figure 2. Low accuracy with high precision

Results that are precise will be clustered together, but because they are inaccurate they will not be near the target area (true value).

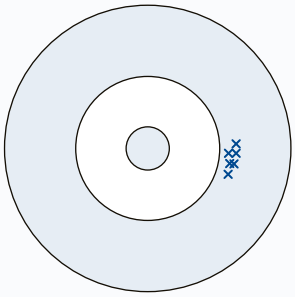
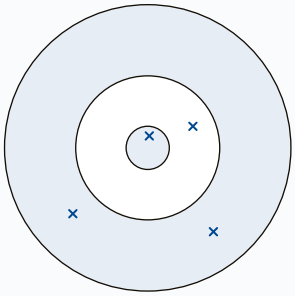


Figure 3. Low accuracy with low precision

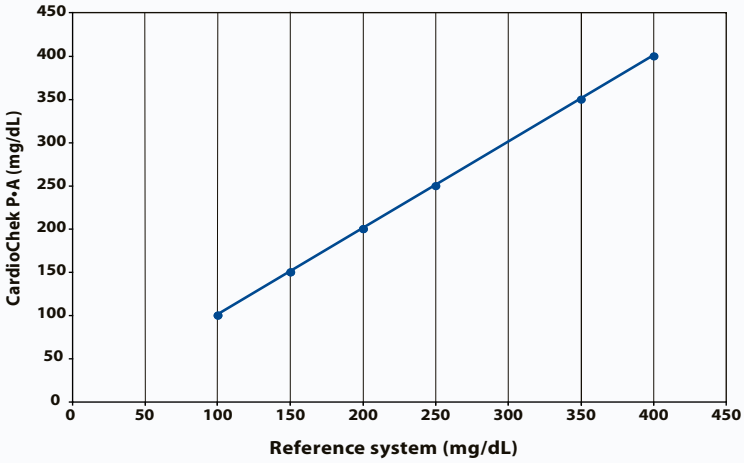
Results with both low precision and low accuracy will be scattered about, and may not be near each other or the target area.



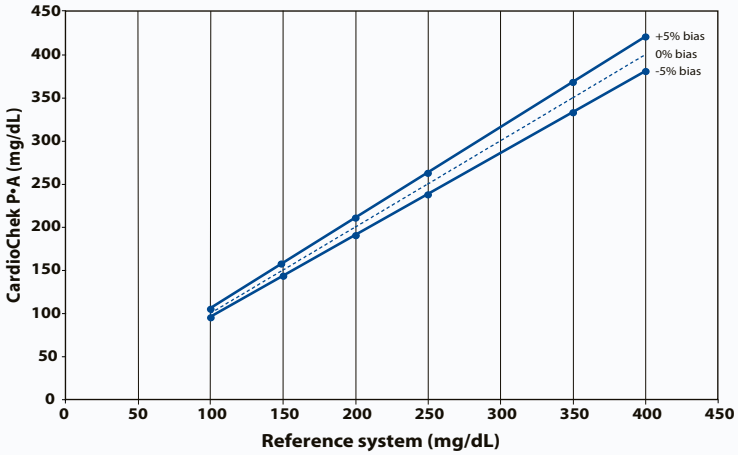
How is accuracy determined?

A primary method for determining accuracy is to compare test results from one method to the values achieved from a method that is accepted as accurate, oftentimes referred to as the gold standard. To clarify this point, let's examine sample results from CardioChek P•A and an accurate reference test.

Accurate results might look like this:



When there is some inaccuracy (bias), the graph will look like this:



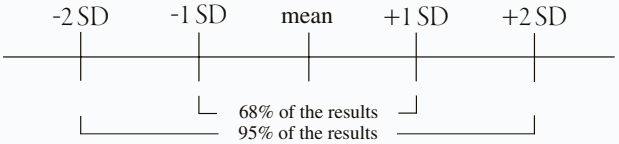
Variables that influence accuracy

Bias, a function of accuracy, is used to describe how far results are from the true value, but bias does not tell the whole story. The precision of the results must also be considered.

Precision is often discussed in terms of the **standard deviation (SD)** and the **percent coefficient of variation (% CV)**. SD is a measure of how spread out the data points of a sample are.

$$1\,SD = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}}$$

Statistics demonstrate that in normally distributed data sets, 68% of the results will fall in a range that is within 1 SD of the mean and 95% of the results will fall within 2 SD of the mean.



The % CV is another measure of the variability of data that allows comparison of data across different data sets. The % CV is defined as SD as a percent of the average value.

$$\%\ CV = \frac{1\,SD}{\bar{x}} \times 100$$

Once the accuracy (bias) and precision (% CV) of an instrument have been calculated, one can determine a critical measurement known as the **total error (TE)**.

The calculation for TE is:

$$TE = \%\ Bias + 1.96 \times \%\ CV$$

The TE is important in determining the acceptable range of systematic and random errors.

The **coefficient of determination (R^2)** is a statistical measure of how well a model approximates real data points. In other words, R^2 shows what is generally referred to as the "goodness of fit" of a model. In cases with a single variable, such as this paper, it is the square of the correlation coefficient (r), which shows the tendency of two variables to move together. R^2 can range from 0 to 1; the closer to 1 the better the model fits the data.

Conclusion

CardioChek P•A Point-of-Care Test System met the stringent CRMLN criteria for Total Cholesterol and HDL Cholesterol based on accuracy, precision, and total error (TE). The LDL Cholesterol showed excellent correlation to the CRMLN as well as excellent precision.

Although CRMLN does not offer certification for triglycerides, these results compared favorably in terms of accuracy and precision to automated methods run at the CRMLN Laboratory.

Point-of-care testing systems, such as the CardioChek P•A System, offer physicians an alternative to traditional laboratory-based blood tests and provide greater flexibility and efficiency in performing routine in-office testing. Additionally, CardioChek P•A allows physicians to obtain immediate results and offer patients face-to-face counsel to help manage their condition.

CardioChek P•A System has documented traceability to the National Reference System for Cholesterol and meets the National Cholesterol Education Program performance criteria for accuracy and precision.

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Reference:

1. Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). *JAMA*. 2001;285(19):2486-2497.

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