Evaluation of the Current Precision Point-of-Care Blood Glucose Test Strip

Objectives: *To evaluate the performance of the Abbott Diabetes Care Precision Point of Care (POC)[1] Blood Glucose test strip for use with Precision Xceed Pro, Precision Xtra, Precision Xceed, Optium and Optium Xceed meters on capillary, arterial, venous, and neonatal blood samples in clinical and laboratory studies.*

Methods: *The following studies were conducted with the Precision POC test strip. Accuracy and user performance in testing capillary blood specimens were assessed at three diabetes clinics. Results obtained with three lots of test strips were compared to plasma equivalent glucose values from the YSI analyzer.*

Accuracy in testing arterial, venous and neonatal blood specimens were each evaluated at a different medical center. Results obtained with three lots of test strips were compared to those from the YSI or a laboratory plasma analyzer.

Laboratory studies were performed at Abbott Diabetes Care to validate performance of the Precision POC test strip under varied testing conditions.

Results: *The clinical accuracy of the Precision POC test strip was evaluated by comparing 156 capillary blood glucose results from 156 patients using 3 lots of test strips with results obtained by the YSI analyzer. Ninety-nine percent of the Precision POC test strip results agreed within ±15 mg/dL (0.83 mmol/L) of the YSI values at glucose concentrations < 75 mg/dL (4.2 mmol/L) and within ±20% at glucose concentrations ≥ 75 mg/dL (4.2 mmol/L). The medical center studies with arterial, venous and neonatal blood samples also demonstrated good agreement between the Precision POC test strip and the YSI and laboratory analyzers.*

In the laboratory precision study, the coefficients of variation (CV) ranged from 3.0 to 3.4% at glucose levels ≥ 75 mg/dL. At glucose levels below 75 mg/dL, the standard deviations (SD) ranged from 1.5 to 1.8 mg/dL (0.08-.010 mmol/L). The current test strip produced accurate results across a broad hematocrit range (20 - 70%) and a glucose measurement range of 20-500 mg/dL (1.1-27.8 mmol/L) with a minimum sample volume of 0.6 µL. Additional studies showed that no clinically significant effect on the accuracy of the current test strip was observed with wide ranges of oxygen partial pressures and numerous drugs or endogenous substances at high concentrations. In the user performance survey for the Precision POC test strip, the overall mean rating by 183 first-time users was 5.5 (on a 1 to 6 scale with 1 being very difficult and 6 being very easy), indicating that lay users found the current glucose test strip very easy to use.

Conclusions: *These studies verify the clinical accuracy of the Precision POC test strip for capillary, arterial, venous, and neonatal samples when compared to laboratory method results. The Precision POC test strip also had a high acceptance rating by first time users. Additional studies demonstrated that the current test strip maintained accuracy in various challenging conditions that may be encountered in everyday testing.*

Introduction

A current biosensor test strip, based on TrueMeasure technology (Abbott Diabetes Care, Alameda, CA), has been developed for use with capillary, arterial, venous, and neonatal blood samples.

Materials & Method

Glucose in the blood specimen reacts with a NAD requiring glucose dehydrogenase (GDH-NAD) on the test strip. This chemical reaction releases electrons, which are transferred from the enzyme to the electrodes by a mediator. These electrons generate a small current, which is proportional to the concentration of glucose in the specimen and measured by the meter. The test strip has a dual-fill feature that allows the user to apply blood to either the top or the end of the test strip. *(Figure 1)* The blood is automatically drawn into the reaction area. The minimum sample volume required is 0.6 µL and the test time is 20 seconds. The TrueMeasure test strip is branded as: Precision Point of Care, Precision H, Optium Point of Care, Optium H and Precision Xceed Pro. The test strip can be used on the following monitors: Precision POC, Precision Xtra, Precision Xceed, Optium, Optium Xceed and Precision Xceed Pro.

Multicenter clinical studies were conducted to evaluate performance with various specimen types. Additional laboratory studies were performed to validate performance claims under various testing conditions.

Figure 1. Top Fill or End Fill Test Strip

Test Method

The test strip *(Figure 2)* contains three electrodes (working, reference, and fill trigger). The circuit between the fill trigger and the reference electrodes must be detected by the meter before the test will start. The completed circuit is only detected when the applied sample flows beyond the reference and working electrodes to contact the fill trigger electrode *(Figure 3)*. This strip feature minimizes errors due to insufficient sampling and reduces strip waste. Upon application of sufficient sample, the test is automatically initiated.

Figure 2. Three Electrodes

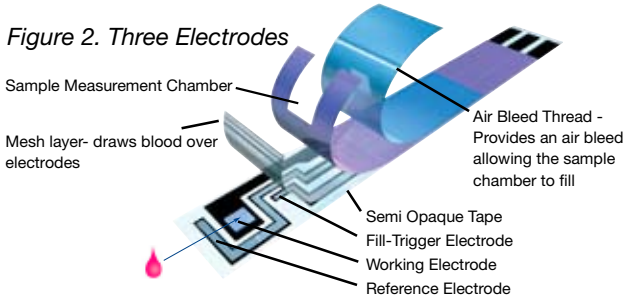
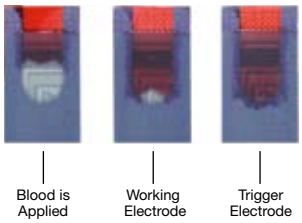
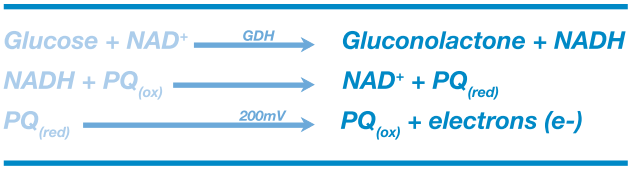


Figure 3. Completed Circuit is Only Detected When Applied Sample Flows Beyond Reference Point



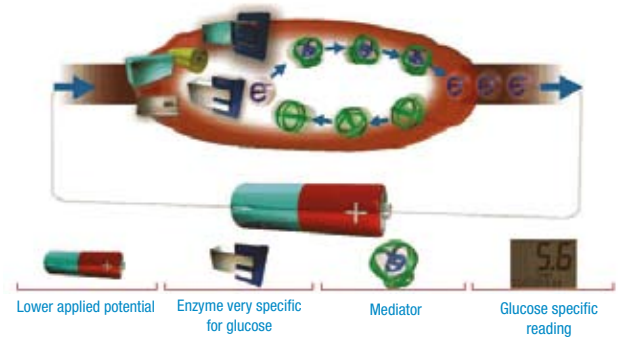
Glucose dehydrogenase (GDH-NAD), coenzyme (NAD), and an electron mediator (PQ) are present on the working electrode of the test strip. The GDH catalyses the oxidation of glucose by NAD to gluconolactone and the coenzyme NAD is reduced to NADH *(Figure 4)*. The electron mediator reacts with the reduced coenzyme (NADH), thus the mediator is reduced and the co-enzyme returns to its oxidized state (NAD). The reduced mediator is oxidized at the working electrode, which produces a small electric current proportional to the glucose concentration in the sample. The current is measured by the monitor.

Figure 4. Chemistry



GDH can be used to perform electrochemical glucose measurements without direct interference by oxygen in the blood sample, thus reducing interfering effects caused by oxygen. The commonly used enzyme in many other electrochemical strips, glucose oxidase (GOX), may react with oxygen to produce measurement errors.

Figure 5. Measurement



Low potential measurements *(Figure 5)* can minimize interference by substances present in the blood sample. For an electrochemical reaction to occur, a potential (voltage) is applied between the working and counter electrode. The larger the applied potential, the greater the number of interfering substances that can be oxidized at the working electrode and produce a signal. The proprietary electron mediator used in these test strips allows the electrochemical reaction to occur at

low potential, so that very few substances interfere with the results. The combination of the fill trigger electrode and the GDH-NAD chemistry with a low applied electric potential is the basis of TrueMeasure technology, designed to minimize errors from insufficient blood samples and interfering substances and thus protect the integrity of glucose testing data from preventable errors.

Comparative Methods

The YSI 2300 Stat Plus Glucose Analyzer (YSI Inc., Yellow Springs, OH) was used as the comparative method in the capillary, arterial, and venous clinical studies and in the laboratory studies. The calibration accuracy of the YSI analyzer at each study site was validated by testing National Institute of Standards and Technology (NIST)[2] secondary reference material SRM 965a, which consists of four levels of glucose concentrations. The YSI whole blood glucose results were multiplied by 1.12 to yield plasma equivalent values. The Vitros (Ortho-Clinical Diagnostics) laboratory plasma reference analyzer was used as the comparative method in the neonatal and the arterial study.

Clinical Studies

The following clinical studies (capillary, arterial, venous & neonatal) were conducted at various diabetes clinics and medical centers in the United States and United Kingdom.

Capillary Study

Accuracy of the Precision POC test strip was evaluated at three centers, each using a different lot of test strips. In total, 156 capillary blood glucose specimens were compared to results obtained on the YSI analyzer. One of the centers is at a high altitude of 7,200 feet or 2,198 meters above sea level.

Arterial and Venous Studies

The results obtained with the Precision POC test strips from 120 arterial blood samples and 67 venous blood samples were compared to those measured by the YSI. The arterial blood samples were also measured by the Vitros laboratory analyzer, after centrifugation of the blood specimens to obtain plasma samples. Comparable agreement was found between YSI and the laboratory chemistry analyzer results when compared to test strip results. Results of arterial and venous blood samples in comparison to the YSI only are presented in this report.

Neonatal Study

The results obtained with the Precision POC test strips from 120 neonatal blood samples were compared to the Vitros Laboratory Reference Analyzer, after centrifugation of the blood specimens to obtain plasma samples.

User Testing

A total of 183 lay users at three diabetes clinics participated in the user performance evaluation. The ages of the subjects ranged from 14 years to 78 years. Forty-six percent of the subjects were male and 54% were female. Their education levels spanned from junior high school to graduate degrees.

After reading the instructions for use and performing a glucose test on their own, the lay users in this study were asked to complete a questionnaire rating 11 ease-of-use topics. The topics included handling of the test strips and application of blood specimens. A scale of 1 to 6 was used, with 6 being the highest rating. An overall ease-of-use rating was obtained by averaging all responses.

Laboratory Studies

The following studies were performed at Abbott Diabetes Care.

Precision (Repeatability)

Precision of the Precision POC test strip was assessed at six glucose levels by analyzing heparinized venous blood in 20 successive replicates. Three lots of test strips were tested. At each glucose level, the coefficient of variation (CV) values of the three lots were averaged.

Linearity

Linearity was assessed over two days with three lots of the Precision POC test strips. With each lot, testing was conducted using capillary whole blood, spiked to various glucose concentrations. Twenty-four samples per day were analyzed in duplicate with each lot of test strips and with the YSI.

Sample Volume Requirements

The effect of sample volume on the performance of the Precision POC test strip was evaluated by applying 0.5, 1 and 3 µL of venous blood to the test strips. Three concentrations of glucose were tested on three different days with three lots of test strips. Twenty-four replicates of testing were performed each day for each sample volume and glucose level. For each sample volume, glucose level and test strip lot, the difference in mean percent bias between each volume and the control volume (3 µL) was calculated.

Interference Studies

Sixty-seven substances, at concentrations much higher than normal or therapeutic levels, have been tested for interference on previous versions of the TrueMeasure technology test strip. Differences in the designs between the current test strip and the previous versions may influence the resistance to interference from 26 of the 67 substances, based on their biochemical and electrochemical properties. Thus, those 26 substances were tested on the current test strip. Paired difference testing was performed for most of the substances. Blood samples were obtained in evacuated tubes containing

lithium heparin, pooled and then spiked to a glucose level of approximately 100 mg/dL (5.5 mmol/L). The pooled, spiked sample was divided into two aliquots – a test sample and a control sample. A concentrated solution of the substance was added to the test sample aliquot, and an equal volume of solvent that was used to dissolve the substance was added to the control sample aliquot. Twenty-four strips from each of three lots of the Precision POC test strips were tested with each sample aliquot. An interfering substance is defined as one that produces a bias greater than 6 mg/dL (0.33 mmol/L) from the control sample in the paired difference testing and is confirmed by dose response testing at various concentrations of the interfering substances.

Dose response testing was performed (without prior paired difference testing) to assess a small number of interfering substances. Blood samples were obtained in evacuated tubes containing lithium heparin, pooled and then spiked to a glucose level of approximately 100 mg/dL (5.6 mmol/L). The pooled, spiked sample was divided into six aliquots – four test sample aliquots and two control sample aliquots. Four different concentrations of the test substance (25%, 50%, 75% & 100%) were added to the test sample aliquots, and an equal volume of solvent that was used to dissolve the substance was added to the control sample aliquots (0%), which were tested at the start and end of the test. Twelve test strips from each of the three lots of the Precision POC test strips were tested with each sample aliquot. The maximum concentration of the substance for which impact on performance is deemed not clinically significant (10% increase on the response at control concentration was determined.

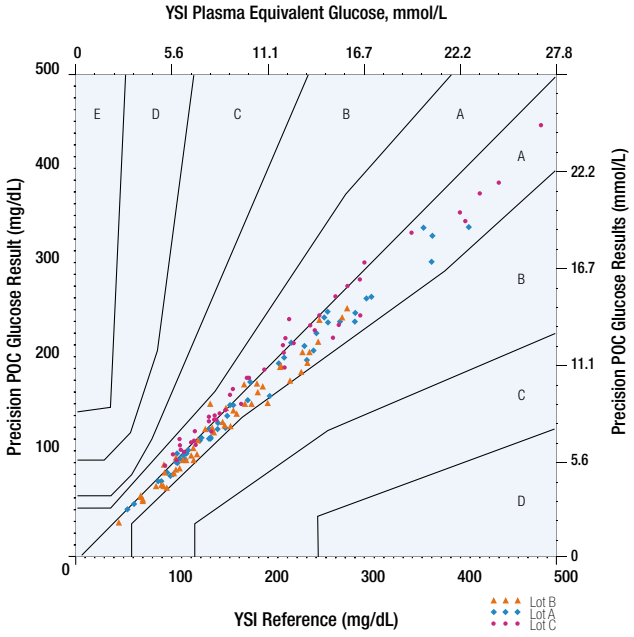
Potential interfering effects from common anticoagulants and blood pH level were also considered.

Clinical Studies Results

Capillary Blood

Excellent correlation was found between the Precision POC test and the YSI analyzer (r = 0.99; slope = 0.92 and intercept = 2.8 mg/dL [0.15 mmol/L] by regression analysis; n = 156 tests [trained operator]; *Figure 6*). Ninety-nine percent of the test strip results were within the ISO accuracy limits. (ISO 15197 specifies that 95% of the individual meter results should fall within ±15 mg/dL (±0.83 mmol/L) of the reference measurement at glucose concentrations <75 mg/dL (4.2 mmol/L) and within ±20% at glucose concentrations ≥75 mg/dL (4.2 mmol/L)[3]. Of the 156 test results, 155 (99.4 %) were in Zone A (clinically accurate) and one (0.6%) was in Zone B (clinically acceptable) of the Consensus Error Grid.[4] The hematocrit range of the capillary specimens in this study was 25-56%, and the range of glucose concentrations was 39-485 mg/dL (2.2–26.9 mmol/L).

Figure 6. Capillary Blood Accuracy



Capillary Blood – Hematocrit Effect

The effect of hematocrit on the test result was assessed by comparing the percentage bias to hematocrit levels – *Figure 7* includes both lay user and trained operator data. Regression analysis was performed to correlate the percentage bias (i.e., difference between test strip results and the reference) with hematocrit levels. Biases at various hematocrit levels were then calculated based on the regression statistics. Relative to a control condition of 45% hematocrit (mid-point of the normal range), test strips results increased 4.1% as hematocrit reached 30%, and decreased 2.7% as hematocrit reached 55% *(Table 1)*. These magnitudes of changes associated with hematocrit levels are clinically acceptable.

Figure 7. Capillary Blood – Hematocrit Effect

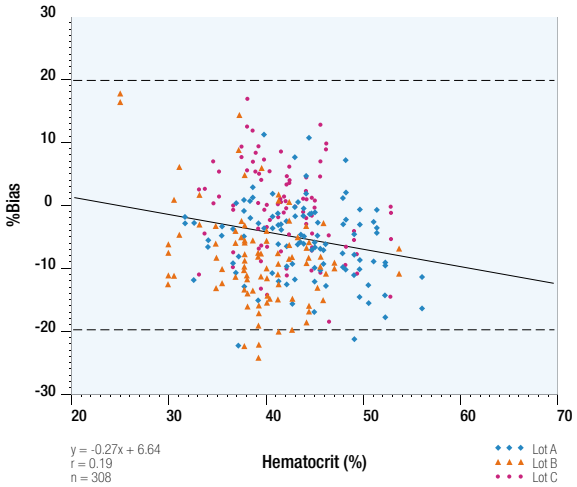


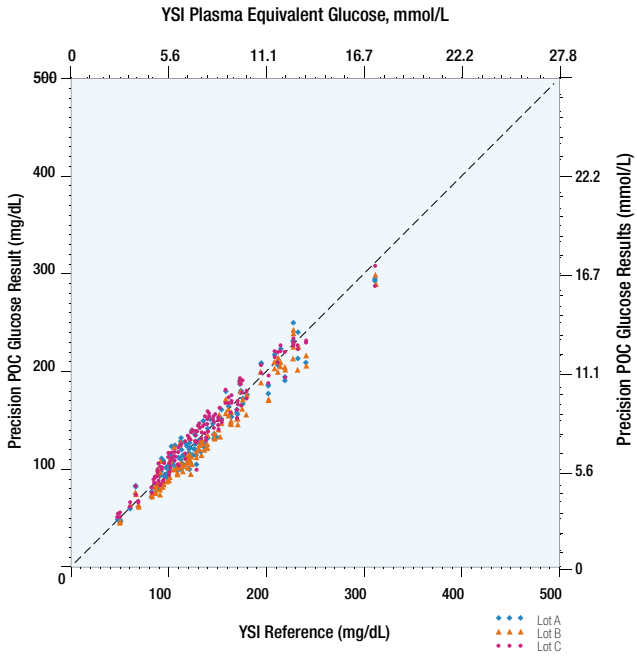
Table 1. Capillary Blood – Hematocrit Effect

Capillary Blood Hematocrit, %	% Bias from Reference	% Bias from 45% Hematocrit
30	-1.5	4.1
45	-5.5	0.0
55	-8.2	-2.7

Arterial Blood

Arterial blood samples from 120 subjects (117 subjects included in analysis; results of three subjects were excluded due to protocol deviations) were tested in duplicate on 3 lots of test strips. The results of the Precision POC test strips for arterial blood correlated well with the results of the YSI analyzer (r = 0.97; slope = 0.99 and intercept = 1.1 mg/dL [0.06 mmol/L] by regression analysis; n = 701 tests) as shown in *Figure 8*. Ninety-nine percent of the test strip results agreed within ±15mg/dL (0.83 mmol/L) of the YSI values at glucose concentrations < 75 mg/dL (4.2 mmol/L) and within ± 20% at glucose concentrations ≥ 75 mg/dL (4.2 mmol/L). The pO2 of the samples in this study ranged from 44 to 352 mm Hg (approximately 6-47 kPa); the hematocrit levels ranged from 19% to 50%; and the glucose concentrations ranged from 43 to 311 mg/dL (2.4 to 17.3 mmol/L).

Figure 8. Accuracy with Arterial Blood



Arterial Blood – Hematocrit Effect

The effect of hematocrit on the test result was assessed by comparing the percentage bias to hematocrit level *(Figure 9)*. Regression analysis was performed to correlate the percentage bias with hematocrit levels. Relative to a control condition of 45% hematocrit (mid-point of the normal range), test strip results increased 6.8% as hematocrit dropped to 20% *(Table 2)*. This magnitude of change associated with extreme hematocrit levels is clinically acceptable.

Figure 9. Arterial Blood – Hematocrit Effect

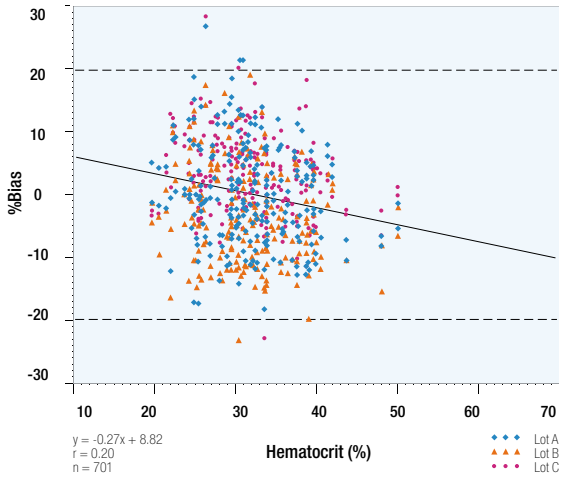


Table 2. Arterial Blood – Hematocrit Effect

Capillary Blood Hematocrit, %	% Bias from Reference	% Bias from 45% Hematocrit
20	3.4	6.8
30	0.7	4.1
45	-3.3	0.0

Arterial Blood – Oxygen Effect

The effect of oxygen on the test result was assessed by comparing the percentage bias to oxygen level *(Figure 10)*. Regression analysis was performed to correlate the percentage bias with pO2 levels. Relative to pO2 of 90 mm Hg (11.97 kPa; partial pressure of oxygen in capillary blood), test strip results increased 1.1% as pO2 dropped to 45 mm Hg (5.98 kPa) and decreased 6.2% as pO2 increased to 350 mm Hg (46.55 kPa) *(Table 3)*. These magnitudes of changes associated with extreme levels of oxygen are clinically acceptable. pO2 greater than 150 mm Hg (20 kPa) can only be found in patients receiving oxygen therapy[5].

Figure 10. Arterial Blood – Oxygen Effect

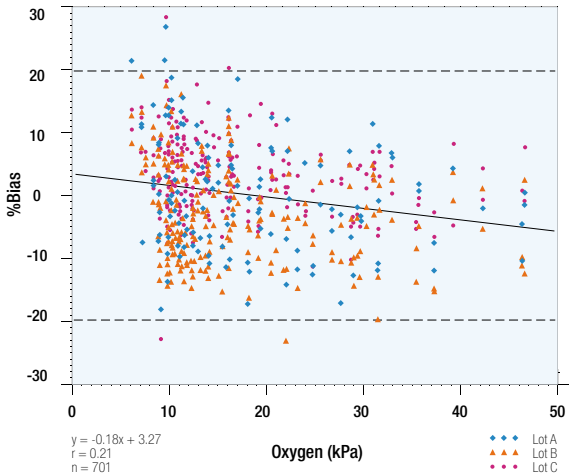


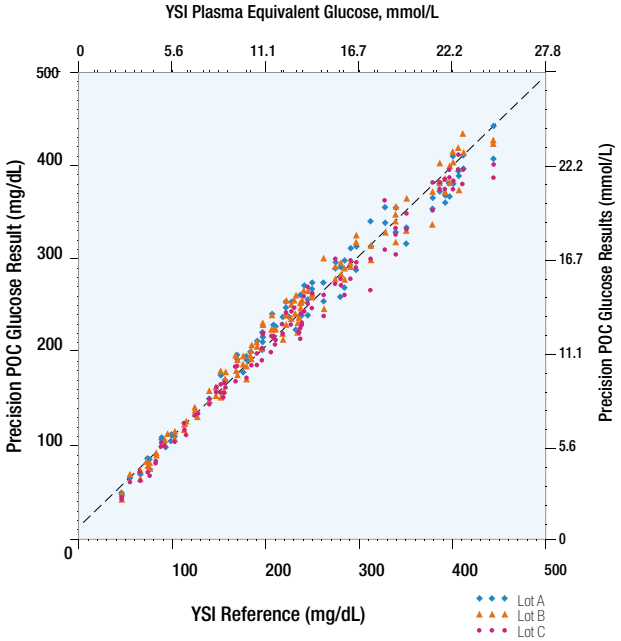
Table 3. Arterial Blood – Oxygen Effect

pO2, mm Hg (kPa)	% Bias from Reference	% Bias from 90 mm Hg
45 (6.0)	2.2	1.1
90 (12.0)	1.1	0
350 (46.6)	-5.1	-6.2

Venous Blood

Venous blood samples from 67 subjects were tested in duplicate on 3 lots of test strips, and the range of glucose concentrations was 44 - 621mg/dL (2.5 – 34.5 mmol/L). The results of the Precision POC test strips for venous blood correlated well with the YSI analyzer (r = 0.99; slope = 0.93 and intercept = 14.2 mg/dL [0.79 mmol/L] by regression analysis; n = 402 tests) as shown in *Figure 11*. One hundred percent of the test strip results agreed within ±15mg/dL (0.83 mmol/L) of the YSI values at glucose concentrations < 75 mg/dL (4.2 mmol/L) and within ± 20% at glucose concentrations ≥ 75 mg/dL (4.2 mmol/L).

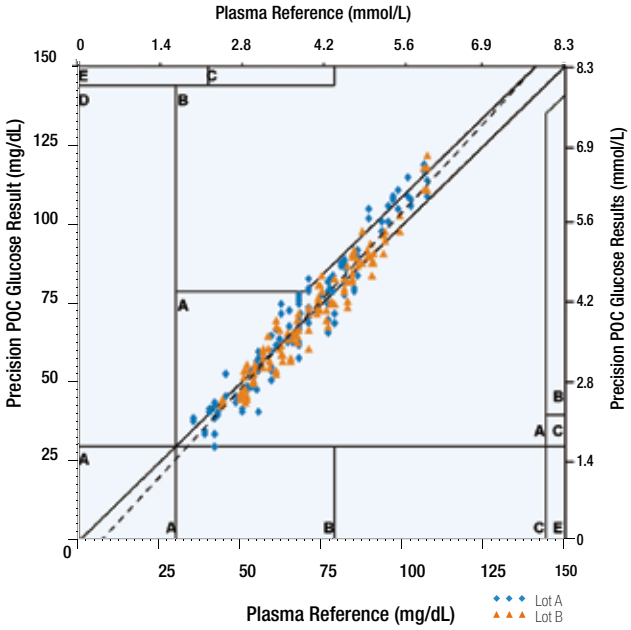
Figure 11. Accuracy with Venous Blood



Neonates Blood

The neonatal study center analyzed 123 samples (120 subjects included in analysis; results on 3 samples were excluded due to protocol deviations.) in duplicate across two lots of test strips between the 6th and 22nd April 2009. The median hematocrit value was 49% (range: 33-66%). The median glucose value was 70 mg/dL (3.9 mmol/L) with a range of 36-108 mg/dL (2.0-6.0 mmol/L). The results of the Precision POC test strip for neonates blood correlated well with the laboratory reference analyzer results (r = 0.97; slope=1.12 and intercept = -7.5 [-0.42 mmol/L] by regression analysis; n = 240 tests) as shown in *Figure 12*. The primary objective of neonatal monitoring is to detect hypoglycemia6. When compared to the laboratory plasma values, 100% of the Precision POC test strip results were clinically accurate or acceptable according to the Leroux error grid analysis[7]. 100% of the test strip results agreed within ±15mg/dL (0.83 mmol/L) of the laboratory plasma values at glucose concentrations < 75 mg/dL (4.2 mmol/L) and within ± 20% at glucose concentrations ≥ 75 mg/dL (4.2 mmol/L).

Figure 12. Accuracy with Neonatal Blood



User Performance Evaluation

One hundred eighty-three lay users at three study centers completed a questionnaire rating the Precision POC test strip for ease-of-use. A scale of 1 to 6 was used, with 6 being the highest rating. An overall ease-of-use rating of 5.5 was obtained when all responses were averaged, indicating that the lay users found the Precision POC test strip very easy to use *(Table 4)*.

The ages of the lay users ranged from 14 years to 78 years old. Forty-six percent of the subjects were male and 54% were female. Their education levels spanned from junior high school to graduate degrees. Twenty percent had Type 1 diabetes and 73% had Type 2 diabetes.

Table 4. Ease-of-Use Rating of the Precision POC Test Strip by 183 Lay Users

Statement	Mean Rating*
It's easy to insert the test strip	5.7
It's easy to apply blood to the test strip	5.4
I like being able to see the blood fill the test strip	5.4
I had enough time to apply blood to the test strip	5.6
It's easy to understand how to use the test strip	5.6
The test is fast	5.3
The test strip uses a small amount of blood	5.1
The test strip is convenient to use	5.3
The test strip is easy to use	5.4
It's easy to learn how to use the test strip	5.7
The test instructions are easy to follow	5.7
Overall Mean	5.5

** The rating scale is 1 to 6 for each statement; 6 is "strongly agree" whereas 1 is "strongly disagree".*

Laboratory Studies

Precision

Repeatability of the current Precision POC test strip, determined as the coefficient of variation (CV) for 60 replicate tests across three lots of test strips using fresh venous blood, ranged from 3.0 to 4.9% *(Table 5)*.

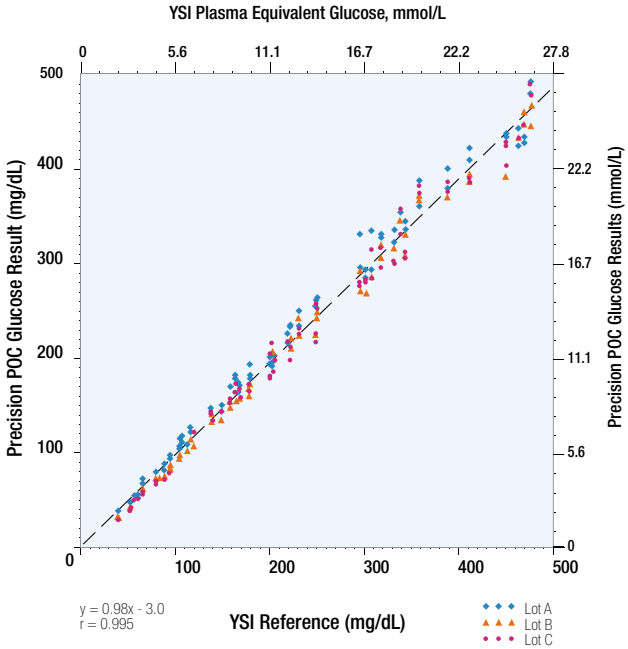
Table 5. Precision

Mean mg/dL (mmol/L)	39.0 (2.2)	60.2 (3.3)	101.9 (5.7)	147.6 (8.2)	230.7 (12.8)	368.2 (20.4)
SD	1.5 (0.08)	1.8 (0.10)				
CV, %	4.9	3.6	3.4	3.3	3.1	3.0

Linearity

Linearity with the Precision POC test strip was demonstrated across the measurement range of 20-500 mg/dL (1.1-27.8 mmol/L) with capillary blood on three lots of the current test strip. Representative data are shown in *Figure 13*.

Figure 13. Linearity Across the Measurement Range



Sample Volume Requirements

Results of using 1 µL sample were comparable to those with 3µL on the three lots of Precision POC test strips studied. The difference in mean percent bias was less than 5% across the lots and the range of sample glucose concentrations (50-350 mg/dL; 2.8-19.4 mmol/L) tested. None of the tests started when 0.5 µL of blood was applied because the sample was insufficient to reach the fill trigger electrode. This finding demonstrates that the Precision POC test strip is designed to minimize inaccurate results due to insufficient sample volume.

Interference Studies

Of the 26 substances tested at high concentrations in the paired difference study, only xylose interfered with the current test strip. Dose response testing for xylose indicates that xylose may produce elevated results at high concentrations found only during the xylose absorption test for diagnostic evaluation of malabsorption. In addition, intravenous infusion of high-dose ascorbic acid may elevate the test strip results. In this circumstance, the concentration of ascorbic acid in the blood can exceed 100 mg/dL (5678 µmol/L) transiently.

*Table 6. Substance Tested for Interference with Precision POC Test Strips**

Substances	Upper Limit of Therapeutic or Normal Concentration		Concentration That Did Not Affect Test Strip Results	
Exogenous				
Acarbose (Glucobay)	-	-	120 mg/dL	1859 µmol/L
Acetaminophen (Tylenol)	***3.02 mg/dL***	***199 µmol/L***	***20 mg/dL***	***1324 µmol/L***
Amoxicillin	-	-	600 mg/dL	16420 µmol/L
Ampicillin	0.5 mg/dL	14 µmol/L	5 mg/dL	143 µmol/L
Ascorbic Acid (Vitamin C)*	***1.5 mg/dL***	***85 µmol/L***	***5 mg/dL***	***284 µmol/L***
Captopril (Lopirin)	-	-	17 mg/dL	782 µmol/L
Cefaclor (Celor)	-	-	23 mg/dL	596 µmol/L
Chloropropamide (Diabinese)	14 mg/dL	506 µmol/L	75 mg/dL	2710 µmol/L
Citric Acid	-	-	30 mg/dL	1563 µmol/L
Diazoxide	-	-	75 mg/dL	3251 µmol/L
Digoxin	1-2 ng/mL	1.3-2.6 nmol/L	100 mg/dL	1280 µmol/L
Diltiazem (Cardizem)	0.02 mg/dL	0.44 µmol/L	75 mg/dL	1663 µmol/L
Dopamine*	***0.03 mg/dL***	***1.6 µmol/L***	***1.44 mg/dL***	***76 µmol/L***
Enalapril (Vasotec)	-	-	8 mg/dL	162 µmol/L
Ephedrine	***1.8 mg/dL***	***89 µmol/L***	***5.4 mg/dL***	***267 µmol/L***
Ethanol	***200 mg/dL***	***43 mmol/L***	***400 mg/dL***	***87 µmol/L***
Ethinylestradiol	-	-	20 mg/dL	675 µmol/L
Fluoxetine (Prozac)	-	-	12 mg/dL	347 µmol/L
Gentisic Acid*	***0.6 mg/dL***	***39 µmol/L***	***7.5 mg/dL***	***487 µmol/L***
Glibenclamide/Glyburide	-	-	0.25 mg/dL	5 µmol/L
Gliclazide (Diamicron)	-	-	32 mg/dL	989 µmol/L
Glipizide (Glucotrol)	-	-	8 mg/dL	180 µmol/L
Ibuprofen (Montril, Advil)	***7 mg/dL***	***340 µmol/L***	***50 mg/dL***	***2427 µmol/L***
Icodextrin	***-***	***-***	***460 mg/dL***	***4600 mg/L***
Levadopa*	***0.2 mg/dL***	***10 µmol/L***	***0.6 mg/dL***	***30 µmol/L***
Methylhydroxyprogesterone	-	-	30 mg/dL	776 µmol/L
Metformin (Glucophage)	-	-	50 mg/dL	3019 µmol/L
Methyldopa (Aldomet)	***0.75 mg/dL***	***35.55 µmol/L***	***1.5 mg/dL***	***71 µmol/L***
Nifedipine	-	-	18 mg/dL	520 µmol/L
Norethisterone	-	-	150 mg/dL	5026 µmol/L
Omeprazole (Prilosec)	-	-	8 mg/dL	232 µmol/L
Oxalic Acid	0.2 mg/dL	22 µmol/L	10 mg/dL	1111 µmol/L
Quinine	1 mg/dL	31 µmol/L	2 mg/dL	62 µmol/L
Ranitidine (Zantac)	2 mg/dL	57 µmol/L	20 mg/dL	570 µmol/L
Salbutamol (Salbumol)	-	-	16 mg/dL	278 µmol/L
Salicylic Acid (from Aspirin)	***30 mg/dL***	***2.17 mmo/L***	***60 mg/dL***	***4.5348 mmo/L***
Simvastatin (Zocor)	-	-	8 mg/dL	191 µmol/L
Terfenadine	-	-	24 mg/dL	509 µmol/L

Substances	Upper Limit of Therapeutic or Normal Concentration		Concentration Tested That Did Not Affect Test Strip Results	
Tetracycline	***0.5 mg/dL***	***11.26 µmol/L***	***1.5 mg/dL***	***33.78 µmol/L***
Thyroxine Sodium	0.005-0.012 mg/dL	65-155 nmol/L	40 mg/dL	516000 nmol/L
Tolazamide (Tolinase)	***5 mg/dL***	***161 µmol/L***	***15 mg/dL***	***482 µmol/L***
Tolbutamide (Orinase)	***10.8 mg/dL***	***400 µmol/L***	***64 mg/dL***	***2370 µmol/L***
Warfarin (Coumadin)	1 mg/dL	32 µmol/L	10 mg/dL	324 µmol/L
Endogenous				
Acetoacetate	1 mg/dL	0.1 mmol/L	20 mg/dL	2.0 µmol/L
Acetone	2 mg/dL	0.3 mmol/L	60 mg/dL	10.3 µmol/L
B-hydroxybutyrate*	***88.2 mg/dL***	***7 mmol/L***	***378.2 mg/dL***	***30 mmol/L***
Bicarbonate	29 mmol/L	29 mmol/L	36 mmol/L	36 µmol/L
Bilirubin, unconjugated*	***1.2 mg/dL***	***21 µmol/L***	***50 mg/dL***	***855 µmol/L***
Cholesterol	***<200 mg/dL***	***<5.18 mmol/L***	***500 mg/dL***	***12.95 mmol/L***
Cholic Acid		1.5 µmol/L	6.0 µmol/L	6.0 µmol/L
Creatinine	***1.3 mg/dL***	***115 µmol/L***	***4.99 mg/dL***	***442 µmol/L***
Gamma Globulin	1.2 g/dL	12 g/L	3.0 g/dL	30 g/L
Glutathione	-	-	1.0 mg/dL	33 µmol/L
Hemoglobin	***200 mg/dL***	***31 µmol/L***	***200 mg/dL***	***31 µmol/L***
Lactic Acid	20 mg/dL	2.2 mmol/L	100 mg/dL	11.1 µmol/L
Pyruvic Acid	0.9 mg/dL	103 µmol/L	2.0 mg/dL	228 µmol/L
Triglycerides	***<150 mg/dL***	***1.69 mmol/L***	***1500 mg/dL***	***16.95 µmol/L***
Urea	38 mg/dL	13.6 µmol/L	500 mg/dL	178.5 µmol/L
Uric Acid	***7.2 mg/dL***	***0.42 mmol/L***	***23.5 mg/dL***	***1.39 mmol/L***
Sugars				
Fructose	7.5 mg/dL	416 µmol/L	30 mg/dL	1665 µmol/L
Galactose*	***20 mg/dL***	***1.11 mmol/L***	***45 mg/dL***	***2.5 mmol/L***
Sucrose	-	-	50 mg/dL	1461 µmol/L
Maltose*	***110 mg/dL***	***3.21 mmol/L***	***200 mg/dL***	***5.56 mmol/L***
Maltotetraose	***-***	***-***	***60 mg/dL***	***0.9 mmol/L***
Maltotriose	***-***	***-***	***120 mg/dL***	***2.38 mmol/L***
Xylose*	***-***	***-***	***29.06 mg/dL***	***1.94 mmol/L***
Anticoagulants				
Citrate	***-***	***-***	***42 mmol/L***	***42 mmol/L***
EDTA	***-***	***-***	***720 mg/dL***	***37.5 mmol/L***
Heparin	***-***	***-***	***5600 U/dL***	***56000U/L***
PH	***7.35-7.45***	***7.35-7.45***	***7.01-7.74***	***7.01-7.74***

Substances in bold & italic were tested on the current Precision POC test strip; other substances were tested with previous versions of the TrueMeasure technology test strip.[8]

**Data for these substances is from dose response testing.*

Discussion

The point-of-care is a challenging environment for glucose monitoring. The pace is fast, and operators face many distractions. Because blood glucose levels can drive treatment decisions, accurate and reliable testing is critical. To meet this challenge, a POC glucose monitoring system must:

- Deliver accurate results regardless of blood source (i.e., capillary, venous, arterial), hematocrit values, oxygen partial pressures, or presence of potentially interfering substances.

- Safeguard the integrity of the testing process to reduce the risk that operators will unintentionally introduce errors that affect the results.

Both components are essential. Even a system that delivers results consistent with a reference analyzer under laboratory conditions may fail to meet the standard if it is susceptible to user error (e.g., short sampling, strip contamination) under real-world POC conditions. In fact, according to a 7-year hospital study, from 91% to 97% of blood glucose-testing errors are operator-related.[9]

Regarding the current Precision POC Blood Glucose test strip, as much thought and care went into the design of its safeguards to prevent user error as went into the chemistry and technology that produce accurate results.

In the clinical, laboratory, and user studies described in this paper, the Precision POC test strip showed excellent accuracy and ease of use with reduced potential for user error.

Accuracy Under Real-World Clinical Conditions

- **The Precision POC test strip delivers accurate results regardless of blood source.** For capillary, venous, and arterial blood, 99% or more of the results were in the "clinically accurate" Zone A of the Clarke and Consensus Error Grids. For neonates, more than 99% of all results were within Zone A of the Leroux Neonatal Error Grid.

- **The Precision POC test strip maintains accuracy across a wide range of hematocrit values and oxygen partial pressures.** Due to the optimized chemistry, accuracy was maintained across hematocrit values that ranged from 20% to 70%. Oxygen partial pressures from 45-350 mm Hg (6.0-46.6 kPa) had no clinically significant effect on results.

- **The Precision POC test strip minimizes the potential for interference.** The use of low voltage also minimizes the potential for interference from substances commonly found in blood. Twenty-six substances were tested on the current Precision POC test strip. The remaining were tested with the previous version of the test strip. None of the substances tested at high concentrations had a clinically significant effect on results (although xylose may produce elevated results during a xylose absorption test for diagnostic evaluation of malabsorption). In addition, intravenous infusion of high-dose ascorbic acid may elevate the test strip results. In this circumstance, the concentration of ascorbic acid in the blood can exceed 100 mg/dL (5678 µmol/L) transiently.

Convenience and Ease-of-Use

- **First-time users rate the Precision POC test strip as very easy and convenient to use.** The overall mean rating by 183 first-time users was 5.5 (on a scale of 1-6).

- **The Precision POC test strip requires less blood.** The test strip requires only 0.6 µL of blood – 76% to 88% less than other strips that require from 2.5 µL to 5 µL of blood.

- **Blood is easy to apply with the Precision POC test strip.** The user can apply blood to the top or the end of the test strip.

Reduced User Error

- **The Precision POC test strip reduces the risk associated with inadequate sample size.** Erroneous results ranging from 79% lower to 35% higher have been reported when a small drop of blood is used with certain point-of-care blood glucose monitoring systems.[10] The Precision POC test strip's sample detection electrode starts only when enough blood is obtained, minimizing the potential for error from "short" samples. In clinical testing of 0.5 µL, 1 µL, and 3 µL samples, none of the tests started when 0.5 µL of blood was applied because the sample was insufficient to reach the fill trigger electrode.

- **The Precision POC test strip reduces the risk of test strip contamination.** In the POC environment, accidental exposure of test strips in a vial to air and moisture is common. Test strips exposed to air for as little as 2 hours have been shown to cause a -26% bias.[11] Each Precision POC test strip is individually foil wrapped to protect it against air, moisture, and other contaminants.

- **The Precision POC test strip's design prevents the use of expired strips**. Each Precision POC test strip is individually barcoded (for Precision Xceed Pro brand only) on the foil outerwrap. Because the operator must scan each strip prior to use, the system ensures that only strips that have not expired are used.

Conclusion

In conclusion, the studies described in this paper show that the Precision POC Blood Glucose Test Strip delivers accurate, reliable results while providing safeguards to ensure the integrity of the testing process. Specifically, the clinical studies validated the accuracy of the Precision POC Blood Glucose Test Strip for capillary, venous, arterial, and neonatal blood samples when compared to the reference analyzer results. Laboratory studies showed the test strip performs well in the presence of interfering substances and across wide ranges of hematocrit and oxygen partial pressures. In user performance testing, the strip had a high acceptance and ease-of-use rating among first-time users. With features that can prevent short sampling, strip contamination and the use of expired strips, these results show that the Precision POC Glucose Test Strip is uniquely designed to provide reliable results in the challenging POC environment.

References

[1] Also branded as Precision H, Optium Point of Care, Optium H. The test strip is the same as the Precision Xceed Pro Blood Glucose test strip for use with the Precision Xceed Pro Blood Glucose Monitor.

[2] NIST Standard Reference Materials. http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm

[3] ISO. In vitro diagnostic test system—Requirements for blood glucose monitoring systems for self-testing in managing diabetes mellitus. ISO 15197. Geneva: International Organization for Standardization; 2003.

[4] Parkes JL, Pardo S, Slatin SL, Ginsberg GH. A new consensus error grid to evaluate the clinical significance of inaccuracies in the measurement of blood glucose. Diabetes Care 2000; 23:1143-1148.

[5] Prudden EL, Siggaard – Andersen O, Tietz NW. Blood Gases and pH in Tietz Textbook of Clinical Chemistry, 2nd ed., 1994, p. 1394.

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[7] Leroux M, Seshia MMK. Glucose meter use in nurseries: Error grid values clinical accuracy. Laboratory Medicine 1994; 25:592-595.

[8] References: Data on file, Abbott Diabetes Care Inc.

[9] Nobels F, Beckers F, Bailleul E, De Schrijver P, Sierens L, Van Crombrugge P. Feasibility of a quality assurance programme of bedside blood glucose testing in a hospital setting: 7 years' experience. Diabet Med. 2004 Dec;21(12):1288-91.

[10] Shalapay CE, Cembrowski GS. Effects of applying insufficient blood on three blood glucose monitoring systems. *Clin Chem* 2004; 50(Suppl 6): A169.

[11] Keffer P, Kampa IS. Instability of blood glucose test strips in uncapped vials. Diabetes 1998;47(Suppl.1)A6.