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Validation of a new generation POCT glucose device with emphasis on aspects important for glycemic control in the hospital care

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¹Central Laboratory of the Hospital (Maasstad Lab), Department of Clinical Chemistry, Maasstad Hospital, Rotterdam, The Netherlands
²Department of Internal Medicine, Maasstad Hospital, Rotterdam, The Netherlands

Abstract

Background: Point-of-care (POC) glucose devices are widely used for insulin-dosage decision-making although such an application is not always permitted. In this study, we have evaluated a new generation of POC glucose device, the HemoCue® Glucose 201DMRT (201DMRT), for its suitability for (tight) glycemic control.

Materials and methods: This study was performed according to the CLSI/STARD criteria. The 201DMRT was compared to the laboratory hexokinase glucose method (Siemens Dimension Vista®). The variation among different POC devices and cuvette lot numbers was examined. Additionally, the influence of the partial pressure of oxygen and hematocrit on glucose measurement was investigated.

Results: The 201DMRT showed a good agreement with the laboratory reference method. This was examined using Deming regression analysis, percentage Bland-Altman plot and a modified Clarke-error grid. The total analytical error at the clinically critical glucose concentrations of 5.6, 7.0 and 11.1 mmol/L (101, 126 and 200 mg/dL) was 6.4%, 4.3% and 3.0%, respectively. The total error among the different POC devices and among different cuvette lot numbers was <6.5%.

Glucose measurements on the 201DMRT were not affected by changes in partial pressure of oxygen, whereas changes in hematocrit had influence on the results (3.4% for every 0.10 L/L change in hematocrit).

Conclusions: The 201DMRT device can be used for glycemic control based on analytical results presented. However, the clinical applicability for tight glycemic control must be confirmed in a clinical study.

Keywords: blood glucose; performance; POCT; tight glycemic control.

Introduction

In general hospitals, point-of-care (POC) glucose devices have been used widely since the late 1980s (1). At first, the design and specifications of these devices were not intended for the purpose of monitoring and adjustment of insulin dosing schedules but it has become a regular practice nowadays (1). Even tight glycemic control protocols in the intensive care units (ICUs) are applied, even though the performance of the devices does not always allow such an application (1, 2).

As published recently, in the majority of studies on analytical and clinical validation of POC glucose devices, several important issues are usually not addressed (1). First, the majority of POC glucose devices have not been validated fully according to the CLSI and STARD criteria (3). Second, the wide variation in the results among the different POC glucose devices, even between devices from a single manufacturer, has been described (4). The third issue is that most of the studies do not take into account the influence of important preanalytical issues, including hematocrit (especially important when implementing POC glucose devices on pediatric wards) and partial pressure of oxygen (important in intensive care units) (1, 4). The last important issue is the overall implementation of POC glucose devices in the hospital and the responsibility for these devices hospital-wide: the network of purchase, maintenance, quality control, training and (re)certification of users to achieve the best possible quality, cost-effective care and patient safety.

The aim of this study was to validate a new glucose POC device, the HemoCue® Glucose 201DMRT device (201DMRT). During the validation, we investigated whether this device meets the recently established criteria for the performance of POC glucose meters (3, 4). Furthermore, we have tested the influence of partial pressure of oxygen and hematocrit on the POC glucose result.

Materials and methods

Samples

Samples were collected from patients who provided informed consent of whom glucose was requested for routine analysis from January to March 2011. The samples were obtained by venipuncture in lithium-heparin containing tubes (BD Vacutainer® Blood Collection Tubes).
All samples included in our study fulfilled the CLSI criteria check (NCCLS C30-A2 factors for glucose monitor evaluation studies) and STARD check where applicable (3). For more information see Table 1.

Methods

For the agreement experiments, the glucose concentration was determined with the HemoCue® Glucose 201DMRT (201DMRT) device (3rd generation of devices) and was compared to the 2nd generation, the HemoCue® Glucose 201DM device (Both HemoCue AB, Angelholm, Sweden) as well as to the laboratory reference method (Siemens Dimension Vista®). The POC users of the index test in this study (201DMRT) were blind to the results of the reference method. In both devices, the measurement is performed in microcuvettes according to the same principle, by modified glucose dehydrogenase method. The measurement of the light transmittance occurs at two wavelengths, to enable the correction for turbidity. Both systems are traceable to the isotope dilution-gas chromatography-mass spectrometry (5). The device shows the result as a plasma-equivalent value of whole blood glucose using a factor of 1.11, in accordance with the guideline (6). The major difference between the 201DM and 201DMRT is the design of cuvettes which excludes the possibility of pre-reaction at room temperature.

The laboratory reference method is the Dimension Vista® GLU method (REF K 1039) from Siemens Healthcare Diagnostics Inc., Newark, USA [analytical measurement range 0.06–27.75 mmol/L (1.1–500 mg/dL)]. The Vista® method is an adaptation of the hexokinase-glucose-6-phosphate dehydrogenase method. The imprecision of the 201DM and Vista glucose methods has been tested previously.

The total imprecision for the Vista method was 1.7%, 1.3%, 1.9%, 2.0% at glucose concentrations of 3.9, 7.1, 10.3 and 11 mmol/L (70, 128, 186 and 191 mg/dL), respectively. The imprecision pools were obtained from the national quality control survey in The Netherlands (SKML).

The imprecision experiments of the 201DM and 201DMRT were performed using control material GlucoTrol®-NG (Eurotrol) according to the NCCLS EP-5 protocol. For each concentration level, the total imprecision was calculated from the results of glucose measurements of the pool samples according to the CLSI EP5-A2 protocol: each level was measured twice a day, in duplicate for 20 days. Also with manipulated patient material imprecision experiment was performed to check for matrix effects according to the EP-5 protocol. The patient plasma pools were collected approximately at the clinically important concentrations, freeze-dried and aliquoted for the imprecision experiments. For total error calculations, imprecision results obtained from control material were used.

The influence of hematocrit and partial pressure of oxygen was tested in additional experiments. The hematocrit experiment was performed according to the publication of Wiener with minor modifications (7). Briefly, five randomly taken venous lithium-heparin samples from patients of whom glucose concentration was determined on the Vista method [range 3.5–10.3 mmol/L (63–186 mg/dL)] were used. Samples were centrifuged at 2400 g and 15 minutes at 4°C, and plasma was separated from the erythrocytes. Subsequently, plasma and erythrocytes were mixed in different proportions to achieve an hematocrit ranging from 0.15 to 0.75 L/L.

The influence of the partial pressure of oxygen was explored by means of two experiments. In the first experiment, randomly drawn samples from ICUs of whom partial pressure of oxygen varied

<table>
<thead>
<tr>
<th>No.</th>
<th>Topic</th>
<th>C30-A2 factors</th>
<th>Addressed in our study</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Blood sample</td>
<td>Blood sample type appropriate for monitoring method</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>Blood hematocrit checked to be within monitor’s acceptable range</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>Blood sample collection method</td>
<td>Appropriate anticoagulant, blood additives, or preservatives (if used)</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Catheter is properly flushed of IV solution prior to sampling (if done)</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>5</td>
<td>Skin is cleaned and dried prior to puncture (if done)</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>Blood sample handling</td>
<td>Monitor and reference method are both tested from the same sample</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>Blood is tested (or centrifuges) within 5 min of monitor test. Centrifuged plasma is tested with reference method within 60 min of monitor test</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>Monitor method</td>
<td>Operators are trained to manufacturer’s instructions</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>Monitor is tested in duplicate</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>Reference method</td>
<td>Laboratory method checked for stability and for being within its QC control limits</td>
<td>Yes</td>
</tr>
<tr>
<td>11</td>
<td>Laboratory method is tested in duplicate</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>12</td>
<td>Laboratory method is verified with NIST standard reference materials (optional)</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>13</td>
<td>Statistics and acceptance criteria</td>
<td>Laboratory duplicates are within 4% or 0.22 mmol/L (or else excluded)</td>
<td>Yes</td>
</tr>
<tr>
<td>14</td>
<td>Distribution of glucose in blood samples spans monitor’s measurement range</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>15</td>
<td>Specimen sample size is ≥40 specimen</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>16</td>
<td>For glucose &lt;4.2 mmol/L, monitor result is accurate if within ±0.83 mmol/L of laboratory average</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>17</td>
<td>For glucose ≥4.2 mmol/L, monitor result is accurate if within ±20% of laboratory average</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>18</td>
<td>Individual monitor results are compared to the mean of duplicate results from laboratory analyzer</td>
<td></td>
<td>Yes</td>
</tr>
</tbody>
</table>

N/A, not applicable.
between 50 to 200 mm Hg as measured by ABL725 (Radiometer, Copenhagen, Denmark) were tested on both the ABL725 and 201DMRT. In the second experiment, a sample was ventilated with pure oxygen (100% oxygen, Linde-Gas, Benelux Rotterdam, Netherlands, art. no. ZM 202) and at the resulting partial oxygen pressures, glucose concentration was measured in duplicate on the 201DMRT device and the ABL analyzer.

All tests were performed by three laboratory technicians, one of whom was a leading technician of our POC team, one was a member of the POC education and training team and the last one was a trainee. In all experiments one reference POC device was used, which was chosen randomly and named 201DMRT device #1.

Statistics

The reproducibility and the deviation of the results from the average were calculated by means of the coefficient of variation [CV% = (standard deviation/mean)×100]. The Bland-Altman percentage plots were used to get a percentage deviation of the average independent on the concentration range (8). The agreement between the methods and bias calculation was performed by Deming regression analysis. Also a Clarke-grid and consensus grid plots were used to evaluate the clinical significance of inaccuracies in the measurement of blood glucose concentrations (9). Total error was calculated according to formula as published by Westgard [total error (%)=bias+(1.65×imprecision (%)) (10). According to recent recommendations, glucose measurement should have a total error of ≤6.9% (4).

The imprecision, Deming regression analysis and grid plots were analyzed using EP Evaluator Release 8 software (David G. Rhoads Associates Inc.). Statistical testing was performed by means of SPSS software Release 18.0 (IBM).

Results

Imprecision and method agreement

The total imprecision test results of the 201DMRT determined with control material GlucoTrol®-NG are presented in Table 2. GlucoTrol®-NG concentrations of 2.8±0.8, 6.2±0.9, 10.8±1.2 and 18.5±2.3 mmol/L were used. Also patient material pools were used to verify the imprecisions. At glucose concentrations of 2.5±0.15, 5.0±0.29, 7.7±0.28 and 19.4±0.51 mmol/L (45, 90, 139 and 350 mg/dL), the total imprecisions were respectively 5.1%, 3.9%, 2.8% and 1.5%. On average, no differences between imprecision results of control materials and patient materials were found, although in the range up to 11 mmol/L the imprecision of control pools was lower as compared to the patient pool. Above 11 mmol/L the opposite was the case. The total imprecision results obtained by control material were used for the calculation of total errors at medical decision points.

To evaluate the performance of the 201DMRT in further detail, four different comparison experiments were conducted: 1) comparison of the 201DMRT device #1 to the laboratory reference method, Dimension Vista (Figure 1A); 2) 201DMRT device #1 with a randomly chosen old generation HemoCue 201DM device (Figure 1B); 3) 201DMRT device to device comparison (Figure 1C); and 4) cuvette lot-to-lot comparison performed on 201DMRT device #1 (Figure 1D).

Comparison of 201DMRT device #1 to the laboratory reference method (range 0.1–28.3 mmol/L, n=80) was performed according to the CLSI criteria (NCCLS C30-A2). All results from the 201DMRT glucose device agreed within ±0.83 mmol/L of the Dimension Vista analyzer values at glucose concentrations ≤4.2 mmol/L and within ±20% of the Dimension Vista analyzer values at glucose concentrations ≥4.2 mmol/L. The Bland-Altman percentage plot is depicted in Figure 1A. The mean 201DMRT to Vista glucose percentage bias was −0.6%±5.2%. Three values with glucose concentrations of respectively 0.7, 0.8 and 1.8 mmol/L were considered outliers in the calculation of average percentage bias (positive percentage bias of HemoCue as compared to Vista measurement of respectively 77%, 30% and 24% for the above-mentioned concentration). However, these three values were included in the Clarke-grids plot. In addition, this plot depicts a good agreement, with no deviation per region (Figure 2A).

Comparison of 201DMRT device #1 to the 201DM (n=48) is shown in Figure 1B. In the range from 2.8–20 mmol/L

Table 2  Agreement HemoCue 201DMRT with Dimension Vista and HemoCue 201DM: calculation of bias and total error at medical decision points.

<table>
<thead>
<tr>
<th>Glucose 3.3 mmol/L</th>
<th>Glucose 5.6 mmol/L</th>
<th>Glucose 7.0 mmol/L</th>
<th>Glucose 11.1 mmol/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVa %</td>
<td>Biasa %, %</td>
<td>TEa, %</td>
<td>CVa %</td>
</tr>
<tr>
<td>201DMRT® vs. 80 (0.1–28.2)</td>
<td>4.4</td>
<td>2.91b</td>
<td>9.2</td>
</tr>
<tr>
<td>201DMRT® vs. 48 (2.6–22.5)</td>
<td>3.1</td>
<td>7.94b</td>
<td>12.9</td>
</tr>
</tbody>
</table>

aCVa (%), total imprecision, is determined on HemoCue® Glucose 201DMRT device #1 (reference device) with cuvette lot #1, with control material Glucotrol. bThe mean percentage bias is given in the text (see Results section). cCalculated bias among the compared methods for given concentration [= (absolute average bias/predicted concentration Y)×100] by Deming regression at given concentration. Deming regression analysis gave for 201DMRT vs. Vista comparison a slope of 1.029 (range 1.003–1.054), an intercept of −0.336 (−0.769–0.097), R=0.997, S0.083. Deming regression analysis gave for 201DMRT vs. 201DM comparison a slope of 1.024 (range 1.004–1.045), an intercept of −0.836 (−0.317 to 0.248), R=0.998, S0.306. dTotal error is calculated using the Westgard formula: TE=bias% +1.65×CVa,%.
(50–360 mg/dL), the mean percentage bias was –1.5% ± 2.0%.
A correlation coefficient of 0.998 was found, confirming
that the number of samples included in this study was suf-
ficient. Overall, a very good agreement over the tested range
was observed. Additionally, the Clarke-grid plot showed an
acceptable agreement with no deviation per region (Figure
2B). The results of Deming regression analysis mean absolute
bias and total allowable error for all correlation experiments
are listed in Table 2.

The total allowable error was calculated at three clini-
cally important glucose concentrations; 5.6, 7.0 and 11.1
mmol/L (100, 126 and 200 mg/dL). At these concentra-
tions the total allowable error was ≤ 6.9%, in all the com-
parisons, except for the comparison of the 201DM and
201DMRT: at 5.6 mmol/L (100 mg/dL), the total allowable
error was 9.4%.

In the POC device to device comparison experiment
(Figure 1C, n=80), three 201DMRT devices were compared
to each other using the same cuvette lot number. No signifi-
cant differences between the devices were found (Friedman
test, p=0.977).

On the reference 201DMRT device #1, three different
cuvette lot numbers were compared (Figure 1D, n=80). As
for cuvette lot-to-lot comparisons, no significant differences
were found (Friedman test, p=0.140). The summary of the
data is presented in Table 3.

Partial oxygen pressure and hematocrit influence on
the glucose measurement

In 15 randomly chosen patient samples from the ICU depart-
ment, with partial oxygen pressures ranging from 50.1 to 202
mm Hg, glucose and partial pressure of oxygen were deter-
dined simultaneously by the ABL bloodgas analyzer and the
glucose concentration of the same sample was analyzed sub-
sequently by the 201DMRT POC device. A constant relation-
ship between the ABL and 201DMRT glucose measurement
was found, which was independent on the partial pressure of
oxygen in the sample (Figure 3A). The average 201DMRT
versus ABL glucose ratio was 1.085 ± 0.064, resulting in a
CV of 5.9%. To provide further evidence for the indepen-
dent relation of partial oxygen pressure on glucose measure-
ment, a patient sample was ventilated with pure oxygen.
The mean glucose concentration on 201DMRT was
4.36 ± 0.12 mmol/L (78.56 ± 2.16 mg/dL), with a CV of 2.7%
(Figure 3B). The following equation shows a negligible rela-
tionship between glucose concentration and partial oxygen
pressure, y=0.0002x+4.2705 (r=0.620, p=0.075).
was calculated using linear regression, and was as follows: 
\[ y = -33.77 \times x + 114.64 \]  
\( r = 0.988, p < 0.0001 \).

To study the influence of hematocrit on the 201DMRT glucose measurement, samples with different hematocrit values were analyzed in five independent experiments. The glucose concentration in the samples with hematocrit of 0.45 L/L were designated as 100% glucose concentration (Figure 3C). The relative deviation from this concentration is plotted against the hematocrit (range 0.15 – 0.75 L/L). The results in Figure 3C show that as the hematocrit decreases with respect to the 0.45 L/L value, the glucose concentration measured increases (range +2.4% to +15.2%) and vice versa: an increase in hematocrit with respect to the 0.45 L/L value showed a decrease in the glucose concentration measurement (range –15.9 to –10.3%). This trend was observed in all tested samples, which was independent of the starting glucose concentration. A relation between hematocrit (x) and glucose concentration (y) was calculated using linear regression, and was as follows: 
\[ y = -33.77 \times x + 114.64 \]  
\( r = 0.988, p < 0.0001 \).

**Discussion**

**Validation of HemoCue 201DMRT**

The purpose of this study was the analytical evaluation of a new POCT device for possible use in (tight) glycemic control, with additional data on influence of partial oxygen pressure and hematocrit. For the agreement experiments, general patient data were used. For the experiments in which the influence of partial oxygen pressure was explored, ICU patient data were used. The aim of this study was, however, not to be a clinical study on tight glycemic control, but analytical validation of a new POCT device with respect to the aspects important for clinical application in tight glycemic control.

It is generally accepted that the hexokinase glucose method is used as the general laboratory reference method for glucose measurement (6, 11). The degree in which POC glucose devices correlate with plasma hexokinase measurement of glucose varies between glucose device technologies but is important for tight glycemic control at the ICU (2, 11). In this study, an excellent agreement between the Vista hexokinase reference method and the HemoCue® Glucose 201DMRT device within the measured range was found [2–30 mmol/L (36–541 mg/dL)].

The study described in this paper shows that at clinically relevant glucose concentrations [i.e., 5.6, 7.0 and 11.1 mmol/L (101, 126 and 200 mg/dL)] the total error of the measurement of the 201DMRT remained below 6.5%. Additionally, a good agreement between different devices of the same model and lot numbers was found. Comparison of the 201DMRT to the older version of the device, HemoCue 201DM, yielded a slightly higher total error of 9.4% at 5.6 mmol/L (101 mg/dL). Nevertheless, the total error remained below 10%. In the low glucose range (≤3.3 mmol/L), higher total errors were found, confirming previous findings that solely glucose POC measurement is not enough in the lower range for treatment decisions. Therefore, in the low range confirmation by the laboratory method is still necessary. To explore the low range in more detail, additional data should be collected and both, the laboratory reference method as well as the POC method should be compared to the ‘golden standard’
Recently, a meta-analysis study was published in which the most important criteria for POC glucose measurement were taken into account (CLIA and STARD) that were used to evaluate the quality of published studies. None of the reports confirmed to all 38 STARD and CLSI recommendations (3). The only criterion not addressed in this study is the optional CLIA criterion, which involves the verification of the bias of the laboratory reference method with respect to NIST standard reference material (Table 1).

In recent guidelines on diagnosis and management of diabetes mellitus (12) it is stated that the manufacturers of POC

---

**Table 3** HemoCue 201DMRT: device-to-device and lot-to-lot comparison.

<table>
<thead>
<tr>
<th>Agreement</th>
<th>n</th>
<th>Abs. bias</th>
<th>Deming regression</th>
<th>Intercept (range)</th>
<th>R</th>
<th>S_\text{bs}</th>
<th>p-Value^c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device #1 vs. Device #2</td>
<td>80</td>
<td>0.000</td>
<td>0.997 (0.988–1.006)</td>
<td>0.043 (–0.108 to 0.195)</td>
<td>0.9996</td>
<td>0.243</td>
<td>NS</td>
</tr>
<tr>
<td>(range 0.1–30 mmol/L)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Device #1 vs. Device #3</td>
<td>80</td>
<td>–0.005</td>
<td>0.998 (0.991–1.005)</td>
<td>0.027 (–0.099 to 0.152)</td>
<td>0.9998</td>
<td>0.202</td>
<td>NS</td>
</tr>
<tr>
<td>(range 0.1–30 mmol/L)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lot #1 vs. Lot #2</td>
<td>80</td>
<td>–0.080</td>
<td>0.996 (0.988–1.003)</td>
<td>–0.01 (–0.142 to 0.115)</td>
<td>0.9997</td>
<td>0.206</td>
<td>NS</td>
</tr>
<tr>
<td>(range 0.1–20 mmol/L)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lot #1 vs. Lot #3</td>
<td>80</td>
<td>–0.094</td>
<td>0.993 (0.985–1.000)</td>
<td>0.016 (–0.115 to 0.148)</td>
<td>0.9997</td>
<td>0.211</td>
<td>NS</td>
</tr>
<tr>
<td>(range 0.1–20 mmol/L)</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

^aThe device #1 and lot #1 were used as the reference. Comparisons of device #2 and device #3, as well as lot #2 vs. lot #3 showed good agreement and non-significant differences were found. ^bAbsolute average bias among the compared methods is given. ^cNS, not significant.
glucose devices should improve the imprecision of the current devices with an intermediate goal of limiting total error for 95% of samples to ≤15% at glucose concentration at ≥5.6 mmol/L (101 mg/dL) and to <0.8 mmol/L (14.4 mg/dL) at glucose concentration of <5.6 mmol/L (101 mg/dL) (12). These criteria were also met by the present study. It is also mentioned that a lower total error would be desirable and may prove necessary in tight-glucose-control protocols and to avoid hypoglycemia in all settings (12). However, the proposed quality specifications have been the subject of various discussions and yet, no consensus exists. For example, based on biological variation, glucose measurements should meet performance criteria which are compared to the previous guideline from 2002 stricter meaning an analytical imprecision of ≤2.9% (as compared to ≤3.3%), bias ≤2.2% (as compared to previously ≤2.5%) and a total error ≤6.9% (previously ≤7.9%) (6, 12). The ADA criteria are even stricter, but no manufacturer succeeded to fulfill them (6, 12). Recently, in two modeling studies it was attempted to relate the total error of glucose measurement with its clinical impact expressed as the erroneous insulin dosing (11, 13). A 10% total error was recommended as sufficient enough to avoid handlings which might be risky for the patient. Interestingly, these models show that large insulin dosage errors are mostly a function of imprecision in glucose measurement rather than of bias. If the CV is maintained lower than 8%, then these errors are unlikely to occur (11). Our analysis showed that we met these criteria on imprecision, although the imprecision CV data as observed in our study are higher than those stated in the guideline based on only biological data. Interestingly, in this study the contribution of the bias was in a rule smaller compared to the contribution of the imprecision to the total error, confirming previous findings.

Influence of partial oxygen pressure and hematocrit

Important variables including changes in hematocrit, environmental temperature, hypotension and hypoxia may influence the results of bed-side glucose monitoring (4, 6, 12). These aspects are of clinical importance in ICU patients and pediatric patients (2, 11). POC-device-reported glucose concentrations may be (artificially) lower in capillary samples than in venous or arterial samples from patients with poor perfusion, which potentially could result in insulin dosing errors (1). This is difficult to investigate since glucose measurement should be measured under the same conditions during the hypoperfusion state and as well as oxygenated state. To this end, we have investigated these aspects by controlled changing of partial pressure of oxygen of the sample, while continuously measuring the glucose concentration by 201DMRT. No significant influence of partial oxygen pressure on glucose measurement by 201DMRT was found. Prior to this experiment, it was important to ensure that there is no influence of partial pressure of oxygen on glucose measurement that differ from the ABL device which we used as a reference. Our results show that this was not to be the case. The ratio between the two measurements, ABL glucose and 201DMRT result, remained constant in all samples from IC patients and independent on the partial pressure of oxygen.

Although glucose measurement on the 201DMRT was influenced by hematocrit, it can be well predicted by the suggested apparent relationship (Figure 2C). This study shows that changes in hematocrit had influence on the results (3.4% for every 0.1 L/L change in hematocrit). This implicates that the glucose concentration should be corrected for hematocrit when interpreting the glucose results in pediatric patients or other patients with significant changes in hematocrit value. These results differ from the results of a previous study, where the HemoCue device was not significantly influenced by hematocrit (7). However, at the time that the study was conducted the first generation of HemoCue systems (HemoCue B-Glucose measuring system) was used which did not use plasma correction mode for hematocrit. In contrast, another study using 201DM, showed that the measured glucose concentration was strongly influenced by low hematocrit. In preterm infants, birth weight and parenteral feeding were also important factors contributing to inaccurate results (14).

Conclusions

In conclusion, glucose meters are widely used among hospitals for the purpose of monitoring and making insulin dosage decisions. To the best of our knowledge, this is the first study explicitly stating to be performed according to the CLSI and STARD criteria investigating a new generation of glucose POC device, the 201DMRT for that purpose.

The 201DMRT shows a very good agreement with the reference hexokinase method. The total analytical error at clinically critical glucose concentrations was <6.5%. The results were not influenced by changes in partial oxygen pressure, although influenced by changes in hematocrit in a predictable fashion.

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Conflict of interest statement

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