Comparison of Six Analytical Methods for Blood Sugar Determination

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GOTO, Y., TOYOTA, T. and ISHITOYA, Y. Comparison of Six Analytical Methods for Blood Sugar Determination. Tohoku J. exp. Med., 1974, 112 (3), 279–284 —— Blood sugar contents of three hundred and thirty blood specimens were determined by six different analytical methods, i.e., the glucose-oxidase method (G), the autoanalyser method with Hoffman’s method (A), the Somogyi-Nelson method (S), the o-toluidine method (T), the Momose’s method (M) and the Hagedorn-Jensen method (H). The values determined by micromethods of Hagedorn-Jensen, of Momose and of Somogyi-Nelson are usually higher, and the values obtained by o-toluidine method are mostly lower than those estimated by the glucose-oxidase method. The values determined by the autoanalyser method are most consistent with those of the glucose-oxidase method among the five analytical methods. With the values of six series, the regression equations were obtained as following: A=0.86G+13, S=0.90G+34, T=0.76G+8, M=0.98G+28, H=0.85G+40, S=1.02A+23, T=0.88A-3, M=1.10A+17, H=0.98A+26, H=0.75S-7, M=0.99S+4, H=0.83S+23, M=1.22T+24, H=0.78M+26. —— blood sugar determination; blood glucose

The determination of blood sugar content was attempted early in the nineteenth century. At that time, more than 50 ml of blood were needed for the analysis as reviewed by Bang (1913). Thereafter, especially from the beginning of this century, the analytical method has been improved by many workers not only in the volume of blood specimen but also in the time needed for the estimation. The micromethod was introduced by Bang (1913) and this method was improved by Hagedorn and Jensen (1923). Since the application of this micromethod in clinical studies, numerous findings on the patho-physiology of blood sugar have been accumulated.

In the Folin-Wu era, the true blood sugar value was estimated by a deduction of non-fermentable reducing (substances) value from the total reducing value. The deproteinization by Somogyi’s reagents (Somogyi 1930) was introduced as a method to give the true blood sugar value without fermentation. The term “true blood sugar” has been replaced, however, with the term “blood glucose” since the application of glucose-oxidase method for the blood sugar determination (Saifer

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and Gerstenfeld 1958). In the present time, the blood glucose determination is dealt with a very small amount of blood sample and a precise value is obtained within a few minutes.

The application of a new method in the laboratory work usually resulted in the omission of an old method, and a comparison of values obtained by an old method with those obtained by a new method needs an exchange table. This table may be necessary in many cases, for instance, in a study of the chronological comparison of blood sugar of human beings.

In the present study, the determination of blood sugar was made simultaneously by six different analytical methods with one blood sample to make an exchange table.

MATERIALS AND METHODS

Blood specimens were collected during the oral glucose tolerance test and in a few cases the specimens were obtained during the insulin tolerance test. The specimens, approximately 2 ml, were obtained by antecubital venipuncture with heparinized syringes and were pipetted into the test tubes containing deproteinizing reagents, respectively. The sugar content of one blood specimen was estimated by six analytical methods, i.e., glucose-oxidase method, autoanalyser system with Hoffman’s method (Hoffman 1937), Somogyi-Nelson method, o-toluidine method (Hyvärinen and Nikkilä 1962), Momose’s method (Momose et al. 1961) and Hagedorn-Jensen method (Hagedorn and Jensen 1923). Two tenth ml of blood was used for the Somogyi-Nelson method, 0.5 ml of blood was used for autoanalyser method and 0.1 ml of blood was used for the other four methods. The procedure of the Somogyi-Nelson method and of the glucose-oxidase method was conformed to the description in Frankel and Reitman’s textbook (1963). The enzymatic analysis was performed with Glucostat (Worthington Biochemical Corporation, Freehold, New Jersey). These estimations were made with 330 blood samples. The regression equation between each two determination series, was calculated at the Hirosaki University Calculation Center.

RESULTS

The distribution of the 330 blood sugar values estimated by glucose-oxidase method is shown in Fig. 1. The values range from 20 to 390 mg/100 ml, but most

![Fig. 1. Distribution of 330 blood sugar values determined by glucose-oxidase method.](image-url)
Fig. 2. Relationship between the values determined by glucose-oxidase method and those by the other methods.
of them distribute between 50 to 130 mg/100 ml. The relationship between the values estimated by glucose-oxidase method and those by the other five methods are shown in Fig. 2. The values obtained by autoanalyser method are fairly consistent with those estimated by the glucose-oxidase method except the higher zone exceeding 300 mg/100 ml where the former values are lower than the later. Most of the values estimated by the Somogyi-Nelson method are higher than those estimated by the glucose-oxidase method. On the contrary, the values determined by o-toluidine method are lower than those of the glucose-oxidase method and this tendency is more remarkable if the values are exceeding 250 mg/100 ml. The values determined by the Momose’s method are higher than those of glucose-oxidase method, but they show a tendency to be lower for the values exceeding 300 mg/100 ml.

**TABLE 1. Regression equations and coefficients of correlation among the six analytical methods**

<table>
<thead>
<tr>
<th>y</th>
<th>Glucose-oxidase</th>
<th>Autoanalyzer</th>
<th>Somogyi-Nelson</th>
<th>o-Toluidine</th>
<th>Momose</th>
<th>Hagedorn-Jensen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose-oxidase</td>
<td>–</td>
<td>1.16x−15</td>
<td>1.11x−37</td>
<td>1.31x−10</td>
<td>1.02x−28</td>
<td>1.17x−47</td>
</tr>
<tr>
<td>(0.96)</td>
<td>(0.92)</td>
<td>(0.99)</td>
<td>(0.94)</td>
<td>(0.97)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autoanalyzer</td>
<td>0.86x+13</td>
<td>–</td>
<td>0.98x−22</td>
<td>1.13x+3</td>
<td>0.91x−15</td>
<td>1.02x−26</td>
</tr>
<tr>
<td>(0.96)</td>
<td>(0.94)</td>
<td>(0.99)</td>
<td>(0.99)</td>
<td>(0.97)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Somogyi-Nelson</td>
<td>0.99x+34</td>
<td>1.02x+23</td>
<td>–</td>
<td>1.13x+9</td>
<td>1.01x−4</td>
<td>1.20x−28</td>
</tr>
<tr>
<td>(0.92)</td>
<td>(0.94)</td>
<td>(0.99)</td>
<td>(0.93)</td>
<td>(0.93)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>o-Toluidine</td>
<td>0.76x+8</td>
<td>0.88x−3</td>
<td>0.75x−7</td>
<td>–</td>
<td>0.92x−19</td>
<td>0.90x−28</td>
</tr>
<tr>
<td>(0.95)</td>
<td>(0.98)</td>
<td>(0.99)</td>
<td>(0.93)</td>
<td>(0.96)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Momose</td>
<td>0.98x+28</td>
<td>1.10x+17</td>
<td>0.92x+4</td>
<td>1.22x+24</td>
<td>–</td>
<td>1.28x−33</td>
</tr>
<tr>
<td>(0.94)</td>
<td>(0.95)</td>
<td>(0.93)</td>
<td>(0.93)</td>
<td>(0.90)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hagedorn-Jensen</td>
<td>0.85x+40</td>
<td>0.98x+26</td>
<td>0.83x+23</td>
<td>1.10x+31</td>
<td>0.78x+26</td>
<td>–</td>
</tr>
<tr>
<td>(0.67)</td>
<td>(0.97)</td>
<td>(0.99)</td>
<td>(0.96)</td>
<td>(0.90)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figures in parentheses represent the coefficients of correlation.

The regression equations among the six methods are summarized in Table 1. This table also contains coefficients of correlation. As assumed from the figures, the results show that the values estimated by the Hagedorn-Jensen method, the Somogyi-Nelson method and the Momose’s method are usually higher than those estimated by the glucose-oxidase method. The values determined by the autoanalyser method is fairly consistent with those of the glucose-oxidase method and the values of the o-toluidine method are lower than those of the glucose-oxidase method.

**COMMENT**

Several workers reported the comparison of the analytical methods for blood sugar determination (Dabels and Bast 1963; Mohnike et al. 1963; Schmidt 1963; Nagel et al. 1967). Most of the reports are on a comparison of two or three methods.
Dabels and Bast (1963), comparing the Hagedorn-Jensen method with the enzymatic method, reported that the difference between the two methods, i.e., value of nonglucose reducing substances ("Restreduktion") was 0–40 mg/100 ml in normal subjects and 0–80 mg/100 ml in diabetic patients. Their results indicate that diabetic patients have a higher value of "Restreduktion." Mohnike and his co-workers (1963) also obtained a similar result. This may be probably due to the presence of nephropathy in some of their diabetic patients. The present study, however, shows that this difference does not become greater with an increase in blood sugar as seen in Fig. 2.

In the original description of Momose’s method (Momose et al. 1961), they reported that the values obtained by their method were consistent with those of Hagedorn-Jensen method. The present study supports their result as understood from the equations of Table 1. Our result shows that the difference between the two methods are as small as a technical error.

The Somogyi-Nelson method has been regarded as a method for true blood sugar determination. This study, however, revealed that the value obtained by this method is approximately 20 mg/100 ml higher than that by the glucose-oxidase method. The values obtained by the glucose-oxidase method are regarded as the values of blood glucose. Therefore, the present result indicates that the Somogyi-Nelson method is not a method for true blood sugar determination, but a method by which the nonglucose reducing substances are also estimated as blood sugar, as far as the micromethod is used.

The values obtained by the autoanalyser method is most consistent with those by glucose-oxidase method among the five methods.

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References


