Tear glucose levels in normal people and in diabetic patients

D. K. SEN and G. S. SARIN

From the Department of Ophthalmology, Maulana Azad Medical College, Lok Nayak Jai Prakash Narain Hospital, and Guru Nanak Eye Centre, New Delhi, India

SUMMARY Fifty normal people and 50 diabetic patients were studied by means of an enzymatic method for the glucose content in the blood, tears, and urine before and after the peroral glucose load. In normal subjects the fasting glucose levels in the tears averaged 3·6 mg/100 ml (0·2 mmol/l) and in the diabetic patients it averaged 16·6 mg/100 ml (0·92 mmol/l). As in blood and urine, tear glucose levels are significantly higher in diabetic patients than normal persons both at fasting and after the peroral glucose load test. The fasting tear glucose level did not appear to be a satisfactory index for classifying a person as a diabetic or normal. It was found that after the peroral glucose load test a tear glucose level at 11 mg/100 ml (0·61 mmol/l) resulted in only 4·6% of the diabetics being missed, while 5·8% of the normal persons were misclassified as diabetics.

It has been the practice to obtain blood or urine samples for glucose analysis to detect hyperglycaemia and diabetes mellitus. Collection of a blood sample is not always convenient and of a urine sample is messy. The difficulties are greater in mass surveys for detecting the prevalence of diabetes in a given population. Attention has therefore been drawn to the study of tear glucose to find out if it can be used as an alternative method for the detection of diabetes and hyperglycaemia. However, the data concerning its level in tears remain confusing and contradictory both as regards its normal level in tears and its relationship with hyperglycaemia.1-4

The purpose of this project was to study the relationship between tear glucose and blood glucose in normal people and in diabetic patients before and after the peroral glucose load test. It was also intended to see whether any value of tear glucose could be used to separate diabetics and normal persons.

Patients and methods

Fifty cases of diabetes mellitus attending the Diabetic Clinic of Lok Nayak Jai Prakash Narain Hospital, New Delhi, with no detectable ocular changes were entered into this study. Their mean age was 53·9 years (range 27 to 70 years). There were 32 males (mean age 47·3 years, range 27 to 66 years) and 18 females (mean age 56·7 years, range 40 to 70 years).

Fifty healthy people (mean age 41·7 years, range 22 to 75 years) who reported to the Outpatient Department of Guru Nanak Eye Centre, New Delhi, for refraction were entered as controls. There were 35 males (mean age 44·2 years, range 22 to 75 years) and 15 females (mean age 37·1 years, range 26 to 44 years).

Samples of blood, tears, and urine were collected after overnight fast and without the diabetic patients receiving any antidiabetic drugs. Tear specimens were collected by the method already described.4 All the samples were stored at -20°C and analysed on the same day. An oral load of 100 g of glucose was given to each subject. Further samples of blood, tears, and urine were collected 2 hours after the peroral glucose load test. The samples were analysed by the enzymatic method.6

Results

The mean, standard deviation, and coefficient of variation (CV) of the level of glucose in blood, tears, and urine in normal persons and in diabetic patients during fasting and after the glucose load are given in Table 1. It can be seen that there was considerable variation from one individual to another in fasting glucose level and the level after
the glucose load in blood, tears, and urine both in normals and diabetics. The mean fasting level of glucose in blood, tears, and urine in diabetics was significantly higher (P<0.001) than in normal persons. There was no significant correlation between glucose content of blood and tears among normal persons and diabetics (normals: $r=0.17$, for 48 DF $P>0.10$; diabetics: $r=0.03$, for 48 DF $P>0.10$). A significant rise of glucose level after the glucose load was found in blood, tears, and urine both in normal persons and in diabetics. The mean percentage rise of glucose level in blood, tears, and urine after the glucose load was more in diabetics. The mean percentage rise in the glucose level in tears was more than the percentage rise in blood after the glucose load in diabetic subjects.

On the assumption of a normal distribution an estimate was made of the proportion of diabetics who would be wrongly classified if a particular glucose level in tears and in urine was considered to separate the 2 groups.

**TEARS**

Tables 2 and 3 show the percentage of subjects misclassified with different critical levels of fasting glucose and those after the glucose load. Whereas the fasting glucose level did not appear to be satisfactory for the purpose of classification into diabetics and normal persons, very good results were obtained when the glucose level after the glucose load are considered. For example, with the level of glucose at 11 mg/100 ml (0.61 mmol/l) only 4.6% of the diabetics and 5.8% of the normals would be wrongly classified (Table 3).

**URINE**

None of the glucose values in fasting samples were found to be satisfactory for the purpose of classification into diabetics and normal persons (Table 4). The percentage of diabetics misclassified as normal was too high for all the levels considered, namely, 10 to 17 mg/100 ml (0.56 to 0.94 mmol/l). When the values lower than 10 mg/100 ml (0.56 mmol/l) were considered, the percentage of normal persons misclassified as diabetic were unacceptably high. However, the glucose levels after the glucose load are more satisfactory (Table 5). For example, with

---

**Table 1**  
**Blood, tear, and urine glucose in mg/100 ml in normal subjects and in diabetic patients**

<table>
<thead>
<tr>
<th></th>
<th>Blood</th>
<th>Tear</th>
<th>Urine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fasting</td>
<td>Peroral load</td>
<td>Mean rise</td>
</tr>
<tr>
<td><strong>Diabetics</strong></td>
<td>Mean±SD (%)</td>
<td>Mean±CV SD (%)</td>
<td>Mean±CV SD (%)</td>
</tr>
<tr>
<td></td>
<td>168±7 61.8</td>
<td>280±1 81.6</td>
<td>66.5</td>
</tr>
<tr>
<td></td>
<td>76±5 13.4</td>
<td>107±6 17.0</td>
<td>40±6</td>
</tr>
<tr>
<td><strong>Normals</strong></td>
<td>103±3 18.3</td>
<td>12±2 23.1</td>
<td>40±6</td>
</tr>
</tbody>
</table>

SI conversion: mmol/l = mg/100 ml χ 0.0555.

**Table 2**  
**Misclassification with different critical levels (mg/100 ml) of fasting tear glucose level**

<table>
<thead>
<tr>
<th></th>
<th>Percentage misclassified at level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetics</td>
<td>4</td>
</tr>
<tr>
<td>Normals</td>
<td>0.4</td>
</tr>
</tbody>
</table>

SI conversion: mmol/l = mg/100 ml χ 0.0555.

**Table 3**  
**Misclassification with different critical levels (mg/100 ml) of tear glucose after peroral glucose load**

<table>
<thead>
<tr>
<th></th>
<th>Percentage misclassified at level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetics</td>
<td>10</td>
</tr>
<tr>
<td>Normals</td>
<td>0.4</td>
</tr>
</tbody>
</table>

SI conversion: mmol/l = mg/100 ml χ 0.0555.

**Table 4**  
**Misclassification with different critical level (mg/100 ml) of fasting urine glucose**

<table>
<thead>
<tr>
<th></th>
<th>Percentage misclassified at level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetics</td>
<td>10</td>
</tr>
<tr>
<td>Normals</td>
<td>1.6</td>
</tr>
</tbody>
</table>

SI conversion: mmol/l = mg/100 ml χ 0.0555.

**Table 5**  
**Misclassification with different critical levels (mg/100 ml) of urine glucose after peroral glucose load**

<table>
<thead>
<tr>
<th></th>
<th>Percentage misclassified at level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetics</td>
<td>24</td>
</tr>
<tr>
<td>Normals</td>
<td>7.5</td>
</tr>
</tbody>
</table>

SI conversion: mmol/l = mg/100 ml χ 0.0555.
Tear glucose levels in normal people and in diabetic patients

a critical value of 26 mg/100 ml (1.44 mmol/l) only
7.9% of the diabetics and 5.3% of the normals
would be wrongly classified.

Discussion

Several workers have studied the glucose level in
tears in normal subjects (Ridley 1—65 mg/100 ml
(3.6 mmol/l), Borsellino 2—27 mg/100 ml (1.5
mmol/l), Giardini and Roberts 3—2.6 mg/100 ml
(0.14 mmol/l) Gasset et al. 4—4.1 mg/100 ml (0.23
mmol/l), and Motoji 5—7.2 mg/100 ml (0.4 mmol/l)).
In our study it averaged 3.6 mg/100 ml (0.2 mmol/l)
in normal subjects.

Michail et al. 6 first demonstrated in 1937 the rise
of tear glucose during hyperglycaemia (alimentary
and diabetic). Lewis and Stephens 7 and Giardini 8
studied the level of tear glucose in diabetic patients
and found it to be often raised, though the increase
bore no relationship to blood glucose. Gasset et al. 4
and Motoji 5 found a definite relationship of tear
level to blood glucose and concluded that
hyperglycaemia could be detected by measuring
tear glucose level. However, in the present study,
no significant correlation was found between the
glucose level of blood and tears.

Gasset et al. 4 measured changes in the tear glucose
level following oral glucose load and found an
increase in the tear glucose level in diabetic patients
but no significant rise in the tear glucose level in
normal subjects. Motoji 5 also studied the glucose
level in tears in normal subjects and in diabetics
before and after peroral glucose load. He found
that, while the glucose level in the tears tended to
run parallel with the blood glucose level, the former
tended to be higher for the same blood glucose level
after the peroral glucose load. In our study the mean
percentage rise in the level of tear glucose after the
peroral glucose load was more than the mean
percentage rise in the level of blood glucose both in
normal persons and in diabetics, but it was found to
be higher in the latter.

Since it was found that, after the glucose load,
tear glucose level at 11 mg/100 ml (0.61 mmol/l) was
a reliable guide for classifying a person as diabetic,
tear glucose levels in the postprandial phase or after
giving oral glucose load can be used as a screening
device for picking up diabetic cases. Subjects with
values higher than 12 mg/100 ml (0.67 mmol/l)
could be labelled as diabetics. Subjects with levels
between 9 mg/100 ml (0.5 mmol/l) and 12 mg/100
ml (0.67 mmol/l) could be considered suspicious and
subjected to detailed blood glucose analysis.

This finding can be taken advantage of in surveying
the prevalence of diabetes in a population. Persons
without diabetic symptoms would be less
reluctant to give samples of tears than of blood.
Thus a fairly accurate estimate of the prevalence
of diabetics could be made with less resistance from
the public.

Thanks are due to Mr G. P. Mathur, New Delhi Tuberculosis
Centre, for the help in the statistical analysis of our data.

References

1 Ridley F. The intraocular pressure and drainage of
2 Giardini A, Roberts JRE. Concentration of glucose and
3 Gasset AR, Braverman LE, Fleming MC, Arky RA,
Alter BR. Tear glucose detection of hyperglycaemia.
4 Lewis JG, Stephens PJ. Tear glucose and diabetes. Br J
5 Sen DK, Sarin GS, Mani K, Saha K. Immunoglobulins
in tears of normal Indian people. Br J Ophthalmol 1976; 60:
302–4.
6 Huggett A St G, Nixon DA. Use of glucose oxidase,
peroxidase, and o-dianisidine in determination of blood
and urinary glucose. Lancet 1957; II: 368–70.
7 Borsellino G. Cited by Giardini A, Roberts JRE. Concentration
of glucose and total chloride in tears. Br J Ophthalmol
1950; 34: 737–45.
8 Motoji K. The glucose content of tear fluid in normal and
9 Michail D, Vancea P, Zolog N. Sur l'élimination lacrymale
du glucose chez les diabétiques. C R Soc Biol (Paris)
10 Giardini A. Recherches sur les taux de glucose dans les
larmes chez les sujets normaux et diabétiques. Boll Oculist
Tear glucose levels in normal people and in diabetic patients.

D K Sen and G S Sarin

Br J Ophthalmol 1980 64: 693-695
doi: 10.1136/bjo.64.9.693

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/