

Poor, E.: Basic studies on growth using the method of transplantation in the hamster cheek pouch. *Transplant. Bull.* 5: 153-55, 1958.

⁷ Sak, M. F., and Macchi, I. A.: In vitro insulin-like activity of intact and transplanted pancreas in the golden hamster (*Mesocricetus auratus*). *Amer. Zool.* 2:443-44, 1962 (Abstract).

⁸ Sak, M. F., and Beaser, S. B.: Alloxan diabetes mellitus in the golden hamster (*Mesocricetus auratus*). I. Presence of sacculations in venules of the cheek pouch and their absence in retinal vessels. *Lab. Invest.* 11:255-60, 1962.

⁹ Beaser, S. B., Sak, M. F., and Sommers, S. C.: Influence of insulin therapy and pyelonephritis upon diabetic glomerulosclerosis in hamsters. *Metabolism* 12:704-09, 1963.

¹⁰ Beaser, S. B., Sak, M. F., Donaldson, G. W., McLaughlin, R. J., and Sommers, S. C.: Alloxan diabetes in the golden hamster (*Mesocricetus auratus*). II. Glomerulosclerosis and its relation to diabetic regulation. *Diabetes* 13:49-53, 1964.

¹¹ Scott, N. R.: Rapid staining of beta cell granules in pancreatic islets. *Stain Tech.* 27:267-68, 1952.

¹² Renold, A. E., Martin, D. B., Dagenais, Y. M., Steinke, J., Nickerson, R. J., and Sheps, M. C.: Measurement of small quantities of insulin-like activity using rat adipose tissue. I. A proposed procedure. *J. Clin. Invest.* 39:1487-98, 1960.

¹³ Sak, M. F., Macchi, I. A., and Beaser, S. B.: Postnatal development of beta cells and ILA secretion in the pancreatic islets of the golden hamster. *Anatomical Record* 152:25-34, 1965.

BRIEF NOTES AND COMMENTS

Tongue Surface Test as a Screening Procedure for Diabetes Mellitus

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SUMMARY

A simple method to estimate blood sugar indirectly is presented. Shreds of tissue paper saturated with glucose-oxidase (Tes-Tape, Lilly) are put on the surface of the tongue and the change in color from yellow into green is observed.

In normal subjects all the tests were negative. In diabetics the test was positive in the presence of protracted hyperglycemia. *DIABETES* 15:58-60, January, 1966.

Studies on the vitamin C reserves of the body by means of the tongue surface test described by Giza¹ have been pursued at this Clinic for several years. Recently, use has been made of the method in the detection of diabetes mellitus with the help of glucose oxidase. Miller and Ridolfo² employed this enzyme in a test for detecting sugar on the surface of the skin of the fingers by means of strips of paper impregnated with glucose oxidase (Lilly). Healthy subjects and diabetic patients were tested by holding a piece of moistened indicator paper between the tips of the thumb and second finger of both hands for one minute. The authors of the method sup-

posed that if the paper then changed color, the person examined was suffering from diabetes. In some diabetic patients, positive results of the test were obtained. Unfortunately, positive results were observed also in healthy persons. Other workers³ concluded that the percutaneous test is neither sufficiently sensitive nor reliable.

The present experiments, carried out on healthy and diabetic children, consisted of observing changes in the color of the paper strip when placed on the tongue in relation to the blood sugar levels.

METHODS

The strip of paper impregnated with glucose oxidase was applied to the surface of the tongue for one minute, and the color change read one minute later. The test was judged positive if there was a change in color from yellow to green within two minutes. In accordance with the intensity of the green coloration, the results were recorded as weakly positive (+), moderately positive (++) , positive (+++) or strongly positive (++++).

The blood sugar levels were determined at the same time by Hagedorn and Jensen's method. In order to test the accuracy of the strips, sixty blood sugar estimations were done with a drop of blood serum. The results were concordant with Hagedorn-Jensen's method (coefficient of correlation 0.85). The tests were performed on fasting patients, and at different hours of the day as well as at various times after meals.

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RESULTS

1. *Healthy children.*

Fifty-seven apparently healthy children were examined several times by means of the tongue surface test.

For those examined in the fasting state, the tongue surface tests were negative. Blood sugar levels in these cases ranged from 70 to 120 mg. per 100 ml. When examined after meals, forty-seven of the fifty-seven gave negative tests, and ten were positive. The highest blood sugar level observed in this group was 190 mg. per 100 ml., i.e., the maximum observed in children under physiologic conditions. Re-examination of the ten children who gave positive tongue surface tests but had normal blood sugar levels disclosed that the positive tests were due to glucose contained in some of the foods ingested, such as cakes, honey, jam or candy. When the tests were performed on these children fifteen minutes after rinsing the oral cavity, the results were consistently negative. Further tests were performed in three groups of children who were given candy containing glucose to suck before being examined. Positive results of the tests were obtained in eleven out of twenty-one children. After rinsing the oral cavity, however, the tests were negative in all cases.

Thus it appears that in healthy persons with normal blood sugar levels (70-190 mg. per 100 ml.) glucose does not appear on the tongue, and the tongue surface test is always negative.

2. *Diabetic children.*

These were divided into two groups: (1) those with newly diagnosed diabetes admitted in coma or in precomatose condition and (2) those known to have diabetes and under treatment with insulin.

Group I. There were five children with initial blood sugar levels as follows:

1. F.W., 760 mg. per 100 ml.,
tongue surface test (++++)
2. D.B., 942 mg. per 100 ml.,
tongue surface test (++++)
3. W.S., 412 mg. per 100 ml.,
tongue surface test (++++)
4. K.Z., 420 mg. per 100 ml.,
tongue surface test (++)
5. N.M., 1,100 mg. per 100 ml.,
tongue surface test (++++)
6. T.L., 420 mg. per 100 ml.,
tongue surface test (++)
7. K.S., 390 mg. per 100 ml.,
tongue surface test (++)
8. W.S., 516 mg. per 100 ml.,
tongue surface test (++)

In all cases the tongue surface test was positive, and in those with the highest levels of blood sugar it was strongly positive. While insulin was being administered to these patients, the tongue surface test and blood sugar level determinations were repeated every few hours during a period of 12 to 24 hrs.

Case 1. Serial blood sugar assays showed declining levels, from 760 to 98 mg. per 100 ml. after 8 hrs. The tongue surface test remained positive throughout this time, even when the blood level dropped to 98 mg. per 100 ml. One hour later, the blood sugar level was 118 mg. per 100 ml., and the tongue surface test was negative.

Case 2. Blood sugar 942 mg. per 100 ml., tongue surface test (++++). Insulin caused a gradual drop from 942 mg. per 100 ml. to 112 mg. per 100 ml. in the blood sugar during 15 hrs., while the tongue surface test remained positive.

Case 3. Blood sugar 412 mg. per 100 ml., tongue surface test (++++). The patient was not comatose, and intravenous therapy was not given. The blood sugar level in the course of 16 hrs. decreased to 320 mg. per 100 ml. and the tongue surface test remained positive throughout. After two days, when the blood sugar level was 200 mg. per 100 ml., the test became negative.

Case 4. Blood sugar 420 mg. per 100 ml., tongue surface test (++) . In the course of 19 hrs., the blood sugar level declined from 420 mg. per 100 ml. to 220 mg. per 100 ml., but the tongue surface test continued to give positive results.

Case 5. A patient on insulin therapy suddenly developed hyperglycemia after a dietetic error:

- 2:30 p.m. blood sugar 1,100 mg. per 100 ml.,
tongue surface test (++++)
7:00 p.m. blood sugar 560 mg. per 100 ml.,
tongue surface test (+)
10:00 p.m. blood sugar 330 mg. per 100 ml.,
tongue surface test (+).

Case 6. Blood sugar 420 mg. per 100 ml., tongue surface test (++) . During seven days the blood sugar level declined from 420 mg. per 100 ml. to 246 mg. per 100 ml.; the tongue surface test was constantly positive.

Case 7. Blood sugar 390 mg. per 100 ml., tongue surface test (++) . After 15 hrs. the blood sugar level decreased to 306 mg. per 100 ml.; the test was positive.

Case 8. The child was admitted in a precomatose state. Blood sugar 516 mg. per 100 ml., tongue surface test (++) . In the course of 22 hrs., the blood sugar level declined gradually to 159 mg. per 100 ml.; the tongue surface test remained positive.

Group II. The tongue surface test was performed eighty-five times on twenty-eight children known to have diabetes, treated with insulin. Thirty-four tests were positive, and fifty-one negative. Of the fifty-one instances in which the test was negative, the blood sugar level was normal or slightly elevated in twenty-four (74-200 mg. per 100 ml.). In the remaining twenty-seven instances the test and the results of blood sugar assays were uncorrelated. To elucidate this observation, the patients were re-examined several times. The pH effect of the saliva was excluded. It was found that the greater or lesser permeation of the mucous membrane by glucose is not an individual trait. Variable results were obtained in the same children: sometimes positive when the blood sugar was only moderately elevated, and at other times negative in spite of high levels of glycemia.

Case 1

- 184 mg. per 100 ml., tongue surface test (+)
172 mg. per 100 ml., tongue surface test (+)
400 mg. per 100 ml., tongue surface test (—)
392 mg. per 100 ml., tongue surface test (+)
170 mg. per 100 ml., tongue surface test (+)

Case 2

- 322 mg. per 100 ml., tongue surface test (+)
280 mg. per 100 ml., tongue surface test (+)
426 mg. per 100 ml., tongue surface test (—)

Case 3

330 mg. per 100 ml., tongue surface test (+)

320 mg. per 100 ml., tongue surface test (—).

When the study of these cases was extended over several days, it was found that the result of the tongue surface test depends on the duration of the hyperglycemia. The tongue surface test was positive at blood levels of 180-300 mg. per 100 ml., provided they were maintained for at least 10-12 hrs. On the other hand, the tongue surface test was negative even at high sugar levels, if these appeared suddenly and were transient. For instance

Patient F.W.

8:00 a.m., 130 mg. per 100 ml., tongue surface test (—)

5:45 p.m., 400 mg. per 100 ml., tongue surface test (—)

8:20 p.m., 382 mg. per 100 ml., tongue surface test (—)

6:00 a.m., 240 mg. per 100 ml., tongue surface test (+).

Patient M.Z.

12:00 p.m., 423 mg. per 100 ml., tongue surface test (—)

8:00 a.m., 71 mg. per 100 ml., tongue surface test (—)

9:00 a.m., 199 mg. per 100 ml., tongue surface test (—)

12:00 p.m., 423 mg. per 100 ml., tongue surface test (—).

The same patient, two days later:

8:00 a.m., 333 mg. per 100 ml., tongue surface test (+)

10:00 a.m., 199 mg. per 100 ml., tongue surface test (+)

12:00 a.m., 423 mg. per 100 ml., tongue surface test (+).

Case F.W.—The positive tongue surface test may persist for a fairly long time, while the blood sugar levels are gradually declining, and may still be positive after the blood levels have returned to normal.

2:00 p.m., 760 mg. per 100 ml., tongue surface test (+)

5:00 p.m., 564 mg. per 100 ml., tongue surface test (+)

6:00 p.m., 362 mg. per 100 ml., tongue surface test (+)

8:00 p.m., 184 mg. per 100 ml., tongue surface test (+)

12:00 p.m., 98 mg. per 100 ml., tongue surface test (+)

0:40 a.m., 118 mg. per 100 ml., tongue surface test (—)

8:10 a.m., 172 mg. per 100 ml., tongue surface test (—).

Case M.D.—The positive tongue surface test persisted when the blood sugar level dropped to 140 mg. per 100 ml., then, after 10.5 hrs., it became negative.

Dec. 4

11:00 a.m., 280 mg. per 100 ml., tongue surface test (+)

Dec. 5

9:00 a.m., 422 mg. per 100 ml., tongue surface test (+)

Dec. 6

9:00 a.m., 140 mg. per 100 ml., tongue surface test (++)

2:00 p.m., 361 mg. per 100 ml., tongue surface test (+)

7:30 p.m., 276 mg. per 100 ml., tongue surface test (—).

Case D.M.—In the course of 6 hrs., the blood sugar level declined from 502 mg. per 100 ml., to 154 mg. per 100 ml. The tongue surface test remained positive.

Dec. 9

10:00 a.m., 502 mg. per 100 ml., tongue surface test (+)

4:00 p.m., 154 mg. per 100 ml., tongue surface test (+).

Case T.L.—Blood sugar increased during 10 hrs. from 133 mg. per 100 ml., to 408 mg. per 100 ml.; the tongue surface test was negative. Fifteen hours later when the blood sugar level was 304 mg. per 100 ml., the result of the test was still negative, and did not become positive earlier than 20 hrs. afterwards.

Dec. 4

7:00 a.m., 133 mg. per 100 ml., tongue surface test (—)

5:00 p.m., 408 mg. per 100 ml., tongue surface test (—)

Dec. 5

8:00 a.m., 304 mg. per 100 ml., tongue surface test (—)

1:00 p.m., 420 mg. per 100 ml., tongue surface test (+).

DISCUSSION

In healthy subjects the tongue surface test is always negative. In prolonged hyperglycemia, the test is positive and may therefore be useful in the diagnosis of diabetic acidosis. In children with compensated diabetes under insulin therapy the tongue surface test may be negative in spite of marked hyperglycemia of short duration because the rise in glucose concentration in the lingual mucosa is delayed in relation to the blood glucose level. The actual blood sugar level can be estimated with a fairly high degree of accuracy by performing the test with a drop of blood serum.

REFERENCES

- ¹ Giza, T., and Weclawowicz, J.: Perlingual method for evaluating the vitamin C content of the body. A rapid diagnostic test for vitamin C undernutrition. *Internat. Rev. Vitamin Research* 30:327, 1960.
- ² Miller, O. I., and Ridolfo, A. S.: The skin-surface glucose test. *Diabetes* 9:48, 1960.
- ³ Kelly, M., Rockwell, D. A., and Wulff, J.A.: Value of the skin-surface glucose test as a screening procedure for diabetes. *Diabetes* 12:50, 1963.