

# Less Expensive, Reliable Blood Glucose Self-Monitoring

MAXIMILIAN SPRAUL, MD, GABRIELE E. SONNENBERG, MD, AND MICHAEL BERGER, MD

We examined the reliability of split test strips for blood glucose self-monitoring. One hundred visual readings were performed with each of the following test strips: original Haemoglukotest 20-800 (HGT 1/1; Boehringer-Mannheim, Mannheim, FRG) and Haemoglukotest 20-800 halved either by a splitting device (HGT 1/2 SP) or by a pair of scissors (HGT 1/2 SC). Within the plasma glucose range of 20–360 mg/dl, there was a close correlation between the results of all three test-strip readings and the values obtained by the reference method (Beckman glucose analyzer): HGT 1/1,  $r = .950$ ; HGT 1/2 SP,  $r = .966$ ; and HGT 1/2 SC,  $r = .966$ . Absolute deviations from the reference values were  $17 \pm 2$ ,  $17 \pm 1$ , and  $17 \pm 1$  mg/dl (mean  $\pm$  SE). Analysis of variance did not reveal any significant differences between the values of each of the three procedures compared with the reference method ( $P = .98$ ). These results indicate that visual reading of split test strips is as reliable as the reading of original test strips. A special splitting device is not necessary. Diabetic patients should be advised to use split test strips for blood glucose self-monitoring to reduce costs. *Diabetes Care* 10:357–59, 1987

**B**lood glucose self-monitoring has become a basic component of all intensified strategies of insulin substitution therapy approaching near-normoglycemic control in type I diabetic patients. In many studies it has been proven that results of test-strip readings performed by well-trained subjects are reliable when compared with laboratory reference methods (1–3). Type I diabetic patients perform multiple daily measurements of blood glucose not only for evaluating metabolic control and preventing acute complications but also for obtaining a basis of systematic insulin dosage adjustments. Thus, blood glucose self-monitoring should be addressed as a long-term essential for diabetes care that has important financial implications. Therefore, splitting test strips has been advocated as a reasonable procedure to lower costs. Our study was performed to prove whether this practice can result in reliable blood glucose measurement.

## MATERIALS AND METHODS

**Materials.** For visual blood glucose measurements, Haemoglukotest 20-800 (Boehringer-Mannheim, Mannheim, FRG)—also known as Chemstrips bG—were used in these

studies. Readings were performed with the original test strips (HGT 1/1) and with test strips cut in half with a special splitting device (HGT 1/2 SP) (Strip-Splitter, Medistron, Horsham, UK) or with scissors (HGT 1/2 SC). Haemoglukotest 20-800 reacts with plasma glucose because it consists of a porous substance that keeps away blood cells; the color blocks of the test strips, however, had been calibrated for capillary blood by the manufacturer (4,5). For laboratory determination of plasma glucose, the Beckman glucose analyzer (Fullerton, CA) was used as reference method, and the obtained values were corrected for comparison with whole blood by a 10% subtraction (2,5). Venous blood samples were drawn from diabetic patients with degrees of glycemia from 20 to 360 mg/dl. The blood samples were put into heparinized tubes and were used for visual test-strip readings and, after centrifugation, for the determination with the Beckman glucose analyzer.

**Experimental procedures.** Test strips were read by 10 subjects (patients and lab personnel) who had been specially trained in this procedure (1); none of them had, however, any experience in reading split test strips. Each subject tested 30 different blood samples by the three methods in randomized order: 10 readings with HGT 1/1, 10 readings with HGT

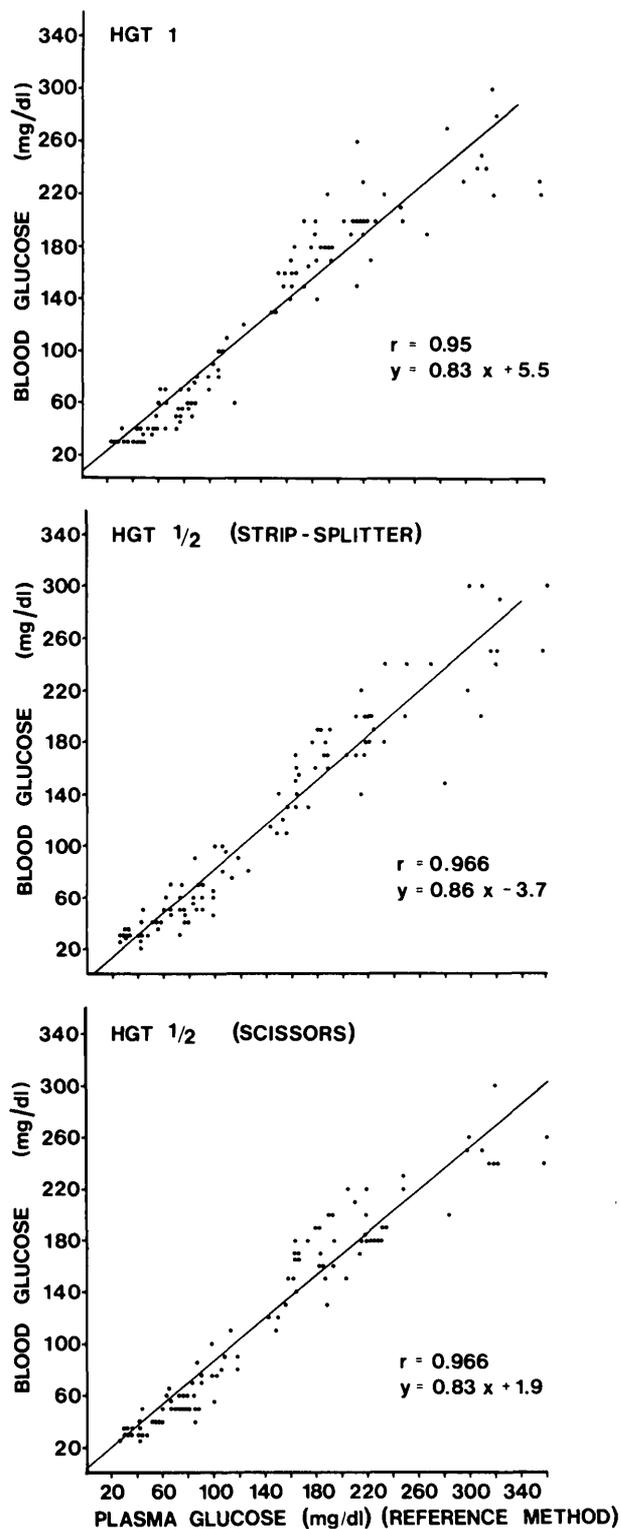


FIG. 1. Correlation between results of test-strip readings and values obtained by reference method (Beckman glucose analyzer; uncorrected plasma glucose concentrations). Test strips were original Haemoglukotest 20-800 (top) and Haemoglukotest 20-800 split either by special splitting device (middle) or by scissors (bottom).

TABLE 1  
 Absolute deviations of test-strip readings from reference values

Blood glucose (mg/dl)	HGT 1/1	HGT 1/2 SP	HGT 1/2 SC
<40	6 ± 1	6 ± 2	5 ± 1
40-79	12 ± 2	14 ± 2	12 ± 1
80-119	11 ± 4	19 ± 4	16 ± 3
120-179	17 ± 3	15 ± 2	18 ± 2
180-239	17 ± 5	19 ± 3	18 ± 3
>240	45 ± 9	34 ± 8	40 ± 7
Mean ± SE	17 ± 2	17 ± 1	17 ± 1

Reference values were measured with a Beckman glucose analyzer to obtain plasma concentrations, and these values were corrected by a 10% subtraction before calculation.

1/2 SP, and 10 readings with HGT 1/2 SC. At the same time and independently of the readers, a lab technician determined the reference values by performing three measurements of each blood sample and calculating the mean.

*Statistical analyses.* Results are given as means ± SE. Correlation coefficients were calculated by linear regression analysis with the uncorrected plasma glucose values of the reference method, whereas for the calculation of absolute deviations between reference and reading results the corrected Beckman values were taken. The BMDP8V computer program (equal cell size mixed models, Department of Biomathematics, University of California, 1980) was applied for the analysis of variance, again with the corrected reference values.

RESULTS

Correlations between the data of the test-strip readings and the reference values are shown for the three reading procedures in Fig. 1. The correlation coefficients demonstrate a highly significant relationship. That the obtained slopes are <1.0 for all three methods (0.83, 0.86, and 0.83) stresses the necessity of converting plasma into blood glucose reference values.

Mean absolute deviations between reference blood glucose values and test-strip reading results were identical for all three methods (17 ± 2, 17 ± 1, and 17 ± 1 mg/dl). In Table 1, mean absolute deviations are presented separately for different blood glucose ranges corresponding to those indicated as color blocks on Haemoglukotest 20-800.

Analysis of variance did not reveal any significant difference between the values of each of the three procedures compared with the reference method (P = .98). The accuracy of reading varied among the subjects: mean absolute differences were 13-24 mg/dl. However, the interindividual variance between subjects did not reach statistical significance (P = .12). There was no significant interrelationship between the subjects' conducting of the readings and the three test-strip methods (P = .61).

## DISCUSSION

**O**ur study demonstrates that test-strip reading with Haemoglukotest 20-800 is a reliable method for blood glucose monitoring when performed by trained subjects. This agrees with previous findings of other authors (1-3). No significant differences were found between the results of original test strips and those of test strips cut in half. Splitting by scissors was as effective as by a special splitting device.

This is the first study investigating the reliability of using split test strips. The advantage is obvious: it halves the cost of blood glucose self-monitoring by a simple procedure. Furthermore, a smaller drop of capillary blood is sufficient. On the basis of these results, the use of split test strips should be recommended to all patients to reduce the cost of blood glucose self-monitoring, which is the most expensive factor of intensified insulin therapy.

ACKNOWLEDGMENTS: This study was supported by the Peter Klöckner Stiftung, Duisburg, FRG.

From the Department of Nutrition and Metabolic Diseases, Department of Medicine, University of Düsseldorf, Federal Republic of Germany.

Address correspondence and reprint requests to Dr. Maximilian Spraul, Medizinische Klinik der Universität Düsseldorf, Abteilung für Ernährung und Stoffwechselkrankheiten, Moorenstrasse 5, 4000 Düsseldorf, FRG.

## REFERENCES

1. Mühlhauser I, Broermann C, Bartels H, Berg R, Schwarz S, Berger M: Qualitätskontrolle der Blutzuckerselbstmessung bei unausgewählten Typ I Diabetikern. *Dtsch Med Wochenschr* 109: 1553-57, 1984
2. Silverstein JH, Rosenbloom AL, Clarke DW, Spillar RP, Pendergast JF: Accuracy of two systems for blood glucose monitoring without a meter (Chemstrip/Visidex). *Diabetes Care* 6:533-35, 1983
3. Marshall SM, Alberti KGMM: Assessment of a new visual test strip for blood glucose monitoring. *Diabetes Care* 6:543-47, 1983
4. Kutter D: *Schnelltests in der klinischen Diagnostik*. Munich, Urban & Schwarzenberg, 1983
5. Silverstein JH, Rosenbloom AL: Test strip comparison: Visidex and Chemstrip. *Diabetes Care* 8:518-19, 1985