TABLE 1
Individual results for each of the 18 patients participating in the study

Patient no.	Mean difference* (G − SMBG) (mg/dl)	r†	PI‡
1	4.1	.861	.837
2	18.5	.823	.830
3	−63.9	.912	.575
4	−36.9	.507	.665
5	12.2	.962	.871
6	−62.3	.823	.514
7	−33.4	.873	.626
8	−22.3	.451	.784
9	62.8	.357	.744
10	−15.3	.944	.785
11	9.2	.104	.886
12	−16.6	.911	.728
13	94.4	.014	.619
14	−19.9	.605	.699
15	33.6	−.794	.810
16	−46.2	.826	.568
17	−18.8	.942	.796
18	47.2	.798	.686
X ± S.D.	−2.0 ± 41.7	0.620 ± 0.446	0.733 ± 0.115

*Mean of differences.
†Coefficient of correlation.
‡Precision index.

the origin, relative to the reference techniqe (N = number of observations by patient). The advantage of this index over the correlation coefficient is that it assumes as a perfect relationship between the G and SMBG techniques a linear regression through the origin with a slope = 1, while the correlation coefficient assumes the general linear regression G = a + b (SMBG): an undesired regression if a $\neq$ 0 and b $\neq$ 1.

The advantage of the index over the usual mean of differences is that it is not meaninglessly decreased by a sum of positive and negative values, which occurs when the observed data cross the linear regression G = SMBG. Moreover, the index gives relative importance to the observed differences.

Thus, we believe that our precision index can be a practical tool for the evaluation of the SMBG techniques. Although the present data illustrate the use of the method, they are not sufficient for its validation. We arbitrarily defined the results as good (PI > .80), fair (PI = .70 to .80), and bad (PI < .70). These values indicate relative errors of <20, 20–30, and >30%, respectively. They seemed reasonable for visual reading strips with differences of 40–60 mg/dl between reference levels in the range of 40–240 mg/dl and the possibility for the patient to extrapolate between these reference levels. However, further studies on larger groups of patients are necessary to better define these criteria, to validate the reliability of the PI, and to establish the number of samples needed for a reliable assessment of a single patient.

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Potential Danger of Extending SMBG Techniques to Hospital Wards

Self-monitoring of blood glucose (SMBG) is a widely accepted technique and is a very helpful adjunct in the outpatient management of diabetes mellitus.[1,2] The fact that

blood glucose levels can be rapidly obtained allows for the appropriate adjustment of insulin, meals, and exercise. Frequent and accurate SMBG is an essential requirement for attempting and achieving "tight" metabolic control. Inaccuracies in SMBG arise from the inherent limitations of the colorimetric assay and technical errors by the operator.

Recently the techniques used to perform SMBG at home have become widely used in the hospital ward.[3] It is hoped that the inpatient management of diabetes would also be improved by a rapid, inexpensive, and easy method for blood glucose determination. Unfortunately, with the decentralization of blood glucose measurements from the central clinical laboratory to the wards, quality control becomes increasingly difficult to assure. The potential hazards of inaccurate measurement of blood glucose levels are obvious. We are, however, unaware of any reports of the reliance on this new technology to measure blood glucose levels leading to adverse incidents in hospitalized diabetic patients, and we therefore wish to report two such cases.

Case 1. The patient is a 72-yr-old man with a 22-yr history of adult-onset diabetes. Adequate outpatient glycemic control was achieved with 30 U NPH and 20 U Regular insulin each morning. Complications of diabetes included mild renal insufficiency, mild to moderate autonomic and sensory neuropathy, and a type IV renal tubular acidosis. The patient was admitted to the surgical service of the V.A. Medical Center for the evaluation and resection of a primary colon carcinoma and a primary bladder carcinoma. Postoperatively, the patient's food intake was poor. Intravenous central hyperalimentation with 25% dextrose was begun in an attempt to speed the patient's recovery. Fingerstick glucoses were monitored 4 times per day on the surgical ward using Chemstrip BG (Boehringer-Mannheim, Indianapolis, IN) with a Glucochek II meter (Larken, Lenexa, KS). A total of eight blood glucose levels were determined and these ranged from a low of 216 mg/dl to a high of 377 mg/dl. Two days after the institution of hyperalimentation the patient was found unresponsive. At that time the blood glucose level determined on the ward was 266 mg/dl, while a simultaneously obtained central laboratory plasma glucose was 1392 mg/dl. Physical examination revealed a dehydrated, comatose thin man with irregular myoclonic activity, blood pressure 120/70 mmHg, pulse 100, and temperature 37°C.

Urinalysis revealed 1% glycosuria with negative ketones. The white blood cell count was 7400. The serum sodium was 151 meq/L, potassium 3.9 meq/L, chloride 105 meq/L, HCO_3^- 36 meq/L, BUN 62 mg/dl, creatinine 2.4 mg/dl, and glucose 1392 mg/dl. An arterial blood gas revealed pH 7.40, pCO_2 28 mmHg, pO_2 94 mmHg. The patient was rehydrated with normal saline and insulin was administered intravenously. Status epilepticus ensued, necessitating intubation, dilantin, phenobarbital, and diazepem administration. Hypotension occurred and dopamine and additional fluids were given. Within several days the patient's mental status returned to its usual state.

Case 2. The patient is a 38-yr-old man with a 20-yr history of juvenile-onset diabetes. Adequate outpatient glycemic control was achieved with 14 U lente and 10 U regular insulin each morning, and 12 U lente and 10 U regular insulin each evening. Complications of diabetes included peripheral neuropathy and osteomyelitis that had required repeated surgical intervention. The patient was admitted to the orthopedic service of the Moffitt-Long Hospital with fever, shaking chills, nausea, vomiting, and epigastric pains. Physical exam revealed a thin man in mild distress with a temperature of 38.5°C, pulse 105, and supine blood pressure 120/70 mmHg. On the right leg was a 1 × 2-cm open wound with necrotic tissue. Edema and erythema surrounded the wound.

Urinalysis revealed ½% glycosuria and a small amount of ketones. The white blood cell count was 8500. Serum sodium was 130 meq/L, HCO_3^- 20 meq/L, BUN 18 mg/dl, creatinine 1.4 mg/dl, and glucose 341 mg/dl. An X-ray of the right foot revealed bone changes consistent with osteomyelitis. The patient was hydrated intravenously and placed on an insulin sliding scale with coverage for blood glucose levels >200 mg/dl. Bacterial cultures were obtained and antibiotics were begun. Fingerstick blood glucoses were measured using dextrostix every 6 h on the hospital ward and the three values obtained were between 130 and 175 mg/dl. At 10:00 a.m. the day after admission the patient was noted to be lethargic. The central laboratory plasma glucose that day at 7:00 a.m. was 494 mg/dl, while the 6:30 a.m. blood glucose on the ward was 175 mg/dl. Further blood tests revealed a plasma glucose of 610 mg/dl at 11:30 a.m. and an HCO_3^- of 11 meq/L. The arterial pH was 7.13. The patient was transferred to the intensive care unit and was treated with fluids and intravenous insulin. Within 24 h his diabetic ketoacidosis was corrected and his lethargy improved.

These cases of diabetes ketoacidosis or hyperosmolar coma point out a potential pitfall of solely relying on bedside glucose monitoring in acutely ill patients with diabetes mellitus. Errors in blood glucose measurement can arise for a number of reasons, including variations in the technical skill of the operator, deterioration of the meters owing to frequent use, and the use of outdated or deteriorated test strips.

As shown in Table 1, the glucose values recorded by the meter used on the hospital ward (meter 1) in Case 1 were consistently less than the expected values. The inaccuracy of this meter was most marked in the higher glucose range. In fact, the glucose values obtained when testing 100 and 200

TABLE 1
Glucose solutions*

Meter	100	200	400	800
1†	84 ± 2 (*N* = 3)	173 ± 8 (*N* = 4)	327 ± 11 (*N* = 3)	Hi (*N* = 2) 378 ± 5 (*N* = 4)
2‡	98 ± 7 (*N* = 3)	204 ± 4 (*N* = 3)	All Hi (*N* = 3)	All Hi (*N* = 3)

*Glucose solutions consisted of glucose (mg/dl) in distilled water.
†Glucocheck II meter used on ward, ‡another Glucocheck II meter.

mg/dl glucose test solutions were frequently within 15% of the expected values. The meters on the hospital wards at the V.A. Medical Center are checked weekly using glucose test solutions in the 100- to 200-mg/dl range and this would account for this inaccurate meter not being detected. Note, as shown in Table 1, that another Glucochek II meter (meter 2) was accurate throughout the range of glucose levels tested. We speculate that the explanation for the falsely low blood glucose levels obtained on the ward in Case 2 were secondary to the technical difficulty in reading high blood glucose values using dextrostix without a meter.

Because of the potential danger of the inaccurate measurement of blood glucose levels in the acute-care setting, we believe that a number of steps to insure accurate determinations should be instituted. In light of our recent experience we recommend corroboration of bedside glucose determinations by simultaneous laboratory determinations at least twice a week in the stable diabetic patient with moderately elevated blood glucoses (<325 mg/dl), exclusive reliance on serum glucose measurements by the clinical laboratory when the patient's glucose levels are <75 or >325 mg/dl, or if the patient is unstable; visual comparison of blood glucose levels with the numerical meter determinations; weekly restandardization of all meters using low, normal, and very high glucose test solutions and removal of dated or deteriorated test strips; thorough instruction of all ward personnel in the proper technique of measuring blood glucose levels; and frequent review of the accuracy of blood glucose measurements carried out on the wards. The use of bedside glucose determinations is a very valuable adjunct to diabetes care but the clinician must recognize that the potential for serious error exists when these tests are used as a sole basis for following diabetic status in acutely ill patients.

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