Short Reports

Hyperglycemic Effect of Sucrose Ingestion in IDDM Patients Controlled by Artificial Pancreas

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The hyperglycemic effect of 28 g sucrose, taken during a mixed meal, was studied in six insulin-dependent diabetes mellitus (IDDM) patients controlled by artificial pancreas. On 2 consecutive days the patients were given, in random order, two Italian meals containing macaroni, bread, meat, vegetables, fruit, olive oil, and an eggnog made with sucrose (meal A) or saccharin (meal B). The two meals were isocaloric and contained equal amounts of carbohydrates. The feedback control on blood glucose continued for 180 min after the meals. Plasma glucose levels and insulin infusion rates delivered by the artificial pancreas after the two test meals did not show any significant differences regarding basal and peak values, peak times, and areas under the curves. A modest amount of sucrose, taken during a mixed meal, does not produce a hyperglycemic effect higher than an equal amount of complex carbohydrates in IDDM patients controlled by artificial pancreas. The same may be expected in well-controlled IDDM patients in conventional therapy because a correlation exists between insulin requirement for conventional therapy and insulin delivered during glucose-controlled insulin infusion. Diabetes Care 12:296–98, 1989

The acceptability of modest amounts of sucrose in the diet of some diabetic patients has been recently stated by the council on nutrition of the American Diabetes Association (ADA; 1), although there is no general agreement on this subject (2,3). Most studies deal with non-insulin-dependent diabetes mellitus (NIDDM) patients, whereas few data are available on insulin-dependent diabetes mellitus (IDDM) patients. Two papers reported the acute effects of sucrose ingestion (4,5), and two others reported the long-term effects of sucrose ingestion in IDDM subjects (6,7). Although the results of the four articles are in agreement with the statement of ADA, the effects of sucrose ingestion were studied only in patients with French or Anglo-American alimentary habits. In our study, we evaluated the acute effect of sucrose ingestion during a typical Italian meal in six IDDM patients controlled by artificial pancreas.

MATERIALS AND METHODS

Patients. Six IDDM diabetic patients (4 men, 2 women) were studied. They were 19–66 yr old (median 43 yr), body mass index was 21.2–23.9 kg/m² (median 22.6 kg/m²), duration of disease was 4–30 yr (median 13 yr), and insulin requirement ranged from 36 to 51 IU/day. Basal and stimulated (glucagon 1 mg i.v.) C-peptide levels were below the detection range of radioimmunoassay in two patients and ranged from 0.2 to 0.4 ng/ml in the remaining four. All patients had normal hepatic and renal function tests. Circulating anti-insulin antibodies, expressed as percentage of binding of ^{125}I-insulin on charcoal-extracted sera, ranged from 18 to 34%; me-

dian 20%. (Insulin binding in 140 nonselected diabetic patients in insulin treatment ranged from 10 to 84%; median 28%.)

Experimental design. Patients gave their informed consent and the ethical committee approved the investigation. Subjects were studied as inpatients. In the three days before the experiment they consumed a diet containing at least 200 g of carbohydrates. The last injection of intermediate-acting insulin was administered 36 h before the test, and afterward patients were treated with regular insulin until the experiment. Each patient was tested twice on consecutive days in random order. After the overnight fast, patients were connected to an artificial pancreas (Betalike Esaote, Biomedica, Genoa, Italy; 8) to achieve normoglycemic equilibrium. Normoglycemia was maintained for at least 1 h before the test meal. At noon, patients were given either meal A or meal B. Meal A consisted of macaroni (40 g dry wt), bread (40 g), grilled meat (100 g), lettuce (150 g), an apple (150 g), olive oil (10 g), eggnog made with whole milk (90 g), eggs (45 g), and sucrose (28 g). Meal B consisted of macaroni (60 g dry wt), bread (60 g), grilled meat (90 g), lettuce (150 g), an apple (150 g), olive oil (10 g), eggnog made with whole milk (90 g), eggs (45 g), and saccharin. Water was permitted as wanted. The two meals contained 40 g protein, 24 g fat, and 110 g carbohydrate. Saturated fat provided ~30% of

total fat. Total dietary fiber content of the meals were 10.8 g (meal A) and 13.2 g (meal B; 13.2 and 16.1 g/1000 cal, respectively). The feedback control on blood glucose continued for 180 min after each meal. Plasma glucose level (enzyme electrode on diluted plasma) and insulin infused were recorded every minute by the artificial pancreas. The algorithm used to control insulin delivery was

$$It = Ibas \times (Ge-Gob/25 + 1)^2 + (fN/fP)(dG/dt) \times Ibas (Ge-Gob)$$

where It is insulin infusion rate (mU/min), Gob the desired glucose level, Ge the measured glucose level, Ibas the basal insulin infusion (mU/min), fN/fP the constants for control of insulin release in response to a rise ($fP = 12$) or a fall ($fN = 6$) in glucose level, and dG/dt the rate of variation of glucose level. Plasma glucose levels recorded at 20-min intervals, insulin infused in each 20-min period, peak values and times to peak of blood glucose, and insulin infusion rate were compared by Student's t test for paired samples (each patient serving as his/her own control).

RESULTS

Plasma glucose levels and insulin infusion rate did not differ significantly with the two meals in any points of the curves (Fig. 1) or in basal and peak values and peak times and areas under the curves (Table 1).

DISCUSSION

Few studies measured the acute effect of sucrose, taken during a mixed meal, in IDDM patients. Bantle et al. (4) showed that a mixed meal containing sucrose had no additional hyperglycemic effect compared with a meal containing an equal amount of complex carbohydrates in IDDM patients treated with subcutaneous insulin. The same result was obtained by Slama et al. (5) studying IDDM patients whose glycemia remained in the normal range by an artificial endocrine pancreas. Because the results of Bantle et al. (4) and Slama et al. (5) cannot be applied to patients with different alimentary habits without any experimental proof, we studied the effect of sucrose ingestion during an Italian meal by performing the same investigation protocol used by Slama et al. (5). Our test meal had a higher content of carbohydrates (53 vs. 47% of total calories), moderately higher content of dietary fiber (16.1 vs. 14.8 g/1000 cal), and a lower content of saturated fat (30 vs. 53% of total fat). Regarding these results, our test meal is compatible with the nutritional recommendations of ADA (1).

In our experiment, performed on a small sample size, we could not demonstrate significant differences in plasma glucose levels and insulin infusion rates delivered by artificial pancreas after the two test meals. Although from a statistical standpoint the benefits of study-
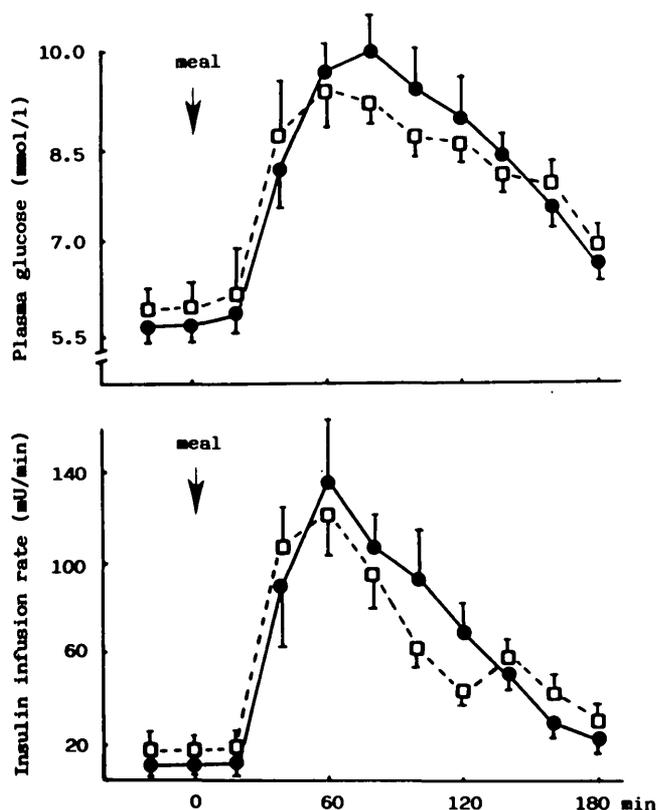

FIG. 1. Plasma glucose levels and insulin infusion rates delivered by artificial pancreas after test meals. Results are means ± SE. □, Meal A; ●, meal B.

TABLE 1
Plasma glucose levels and insulin infusion rates delivered by artificial pancreas after test meals

	Meals		
	A	B	P
Plasma glucose (mM)			
Fasting	5.9 ± 0.4	5.8 ± 0.3	0.9
Peak	9.9 ± 0.4	10.4 ± 0.3	0.4
Peak time (min)	55 ± 13	67 ± 15	0.2
Incremental area of plasma glucose (mM/t)			
0–60 min	136 ± 35	124 ± 17	0.5
0–120 min	353 ± 50	370 ± 33	0.6
0–180 min	514 ± 62	525 ± 58	0.6
Infusion rate (mU/min)			
Fasting	16 ± 2	14 ± 2	0.3
Peak	143 ± 19	161 ± 18	0.5
Peak time (min)	60 ± 9	67 ± 8	0.3
Insulin infused (IU)			
0–60 min	4.8 ± 0.7	4.7 ± 0.9	0.9
0–120 min	8.9 ± 0.8	10.4 ± 1.0	0.1
0–180 min	11.5 ± 0.8	12.7 ± 1.4	0.3

Values are means ± SE.

ing a larger sample size cannot be excluded (some statistically significant differences might appear), P values obtained in our statistical analysis make it unlikely (Table 1).

Sucrose taken during a mixed meal does not produce a hyperglycemic effect greater than an equal amount of complex carbohydrates in IDDM patients controlled by artificial pancreas. The same may be expected in well-controlled IDDM patients in conventional therapy, because a correlation has been found between insulin requirement for conventional therapy and insulin delivered during glucose-controlled insulin infusion (insulin delivered by the artificial pancreas is ~20% higher than that needed in subcutaneous therapy; 9).

Although the results of acute experiments like ours cannot be extrapolated to the longer-term situation, it is possible that moderate amounts of sucrose in the diet of IDDM patients might improve their compliance to the diet without worsening metabolic control.

Glucose 1 mM = 18 mg/dl

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Accuracy of Nurses in Performing Capillary Blood Glucose Monitoring

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The accuracy and outcome of capillary blood glucose (CBG) monitoring as routinely performed by nursing staff were assessed. The sample consisted of 160 readings conducted by 93 nursing staff members in four hospitals; 19% of the readings deviated from simultaneous laboratory results by >20%, and deviations resulted in altered responses to standing orders in 26 patients (17%). There was no statistically significant difference between the total variation attributed within and between nurses, possibly indicating that all nurses should be given the same intensity of follow-up training rather than targeting those who perform incorrectly on