# Basal Insulin Requirement Is ~30% of the Total Daily Insulin Dose in Type 1 Diabetic Patients Who Use the Insulin Pump

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**OBJECTIVE**—To investigate the basal insulin requirement in total daily insulin dose in Japanese type 1 diabetic patients who use the insulin pump.

**RESEARCH DESIGN AND METHODS**—The basal insulin requirement in 35 type 1 diabetic patients without detectable C-peptide using the insulin pump (Paradigm 712) was investigated during 2–3 weeks of hospitalization. The patients were served diabetic diets of 25–30 kcal/kg ideal body weight. Each meal omission was done to confirm stable blood glucose levels within 30 mg/dL variance until the next meal. Target blood glucose level was set at 100 mg/dL before each meal and 150 mg/dL at 2 h after each meal.

**RESULTS**—Total daily insulin dose was 31.6 ± 8.5 units, and total basal insulin requirement was 8.7 ± 2.9 units, which was 27.7 ± 6.9% of the total daily dose.

**CONCLUSIONS**—Basal insulin requirement is ~30% of the total daily dose in Japanese type 1 diabetic patients who use the insulin pump.

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Insulin therapy consists of basal insulin to keep blood glucose level stable and bolus insulin to control postprandial hyperglycemia and to correct hyperglycemia if necessary. Type 1 diabetic patients who run out of their own insulin secretion are recommended to set proper amounts of basal insulin. According to the textbook, total basal insulin dose (TBD) is ~50% of the total daily insulin dose (TDD) (1–3).

The purpose of this study was to assess basal insulin requirement in type 1 diabetic patients, who are on insulin pump therapy, without detectable C-peptide (<0.1 ng/mL). This study was done during 2–3 weeks of hospitalization in patients on diabetic diets.

**RESEARCH DESIGN AND METHODS**—Among 42 Japanese patients treated with the insulin pump, 35 were consecutively selected who met the inclusion and exclusion criteria and who signed an informed consent. We used a Paradigm 712 pump (Medtronic, Northridge, CA) with which we program basal insulin infusion hourly every 0.05 units. All patients used rapid-acting insulin in their pumps and were asked to monitor blood glucose four times daily. To exclude factors that could modify insulin dose requirements (2), the patients were hospitalized in Osaka University Medical Hospital from July 2007 to July 2010 to adjust the insulin pump. We excluded individuals with eating disorders, concomitant dietary restrictions, unstable retinopathy, renal failure, or pregnancy or who were using other antidiabetic agents or steroids. During the 2–3 weeks of hospitalization, an eight-point glucose testing (before and 2 h after each meal [2200 and 0300 h]) was performed to allow optimization of basal insulin rates according to the previous report (4). The diabetic meals in all studies were 25–30 kcal/kg ideal body weight, consisting of 50–60% carbohydrate, 15–20% protein, and 20–25% fat and were prepared by dietitians. Overnight basal insulin rates were evaluated with the blood glucose readings at 2200, 0300, and 0700 h and set using the same method (4). Upon verification of the basal rates, bolus insulin was determined by physicians using carbohydrate counting. All meals were consumed within 20 min; no additional food or drink was consumed unless required to treat hypoglycemia. The target fasting glucose and 2-h postprandial glucose values were set at 100 and 150 mg/dL in each participant. TDD, TBD, and percentage of TBD to TDD (%TBD) were collected after achieving the target glucose level at least for 3 days. The average of the eight-point glucose testing for the final 3 days of the study period was collected. $HbA_{1c}$, TDD, and %TBD at 6 months after the study period in 26 patients were collected. Demographic data are presented as means ± SD.

**RESULTS**—Characteristics of the study subjects were as follows: sex, 11 males/24 females; age, 39.7 ± 10.9 years (20–69) [mean ± SD (range)]; body weight, 56.5 ± 10.0 kg (36–80); BMI, 22.0 ± 3.0 $kg/m^2$ (14.6–28.7); duration of diabetes, 22.1 ± 11.4 years (2–44); $HbA_{1c}$, 7.26 ± 1.40% (5.0–11.5).

The average of the eight-point blood glucose was shown in Fig. 1*A* (*upper panel*). According to the meal omission, basal insulin dose was adjusted in each patient. Basal insulin rate was shown in Fig. 1*A* (*lower panel*). TBD was 8.7 ± 2.9 units (3.3–15.3), TDD was 31.6 ± 8.5 units (18–50), and TDD/kg was 0.56 ± 0.13

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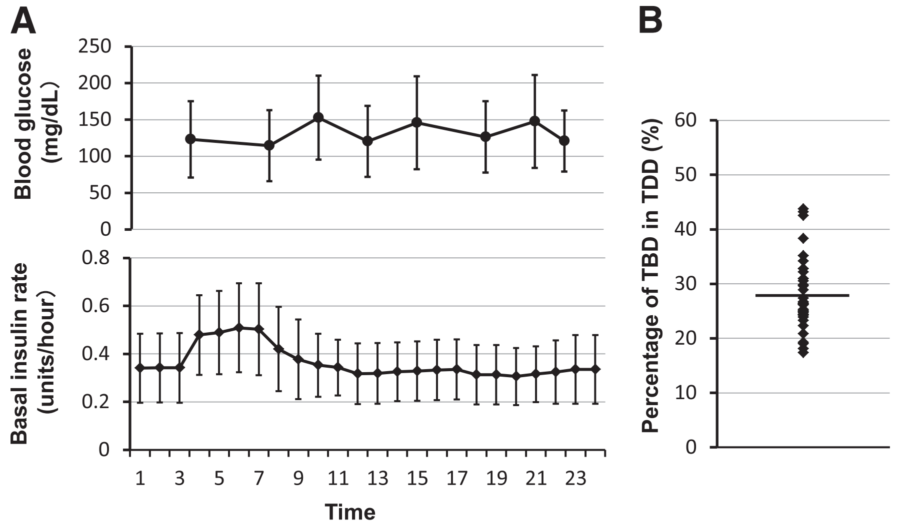


**Figure 1**—A*: Eight-point blood glucose profile during the final 3 days of hospitalization in type 1 diabetic patients using the insulin pump* (upper panel)*. Basal insulin requirement (units/h)* (lower panel) *is shown. Data are expressed as means* ± *SD.* B*: Percentage of basal insulin requirement in TDD. TBD was 27.7* ± *6.9% TDD* (n = *35*).

units/kg (0.32–0.84). As shown in Fig. 1*B*, %TBD was 27.7 ± 6.9% (16.6–43.8). No patients required 50% TDD. In addition, there was no relationship between BMI, age, $HbA_{1c}$, and %TBD (data not shown).

$HbA_{1c}$ changed from 7.42 ± 1.32 to 6.95 ± 1.46% ($P < 0.01$), TDD changed from 32.0 ± 7.8 to 33.9 ± 12.0 units/day ($P = 0.21$), and %TBD changed from 28.9 ± 5.1 to 29.7 ± 6.2% ($P = 0.54$) at 6 months after the study period.

**CONCLUSIONS**—We investigated here the basal insulin requirement in C-peptide–negative type 1 diabetic patients. Our results show that basal insulin requirement is ~30% TDD in the inpatients on diabetic diets prepared by a dietitian (Fig. 1*B*). In addition, the maximal basal insulin requirement in all patients was 43.8% TDD, and no patients required 50% TDD. These results indicate the currently widely published formula (TBD = 0.5 × TDD) (1–3) overestimates the TBD. King (5) also recently suggested that this should be revised to TBD = 0.4 × TDD to prevent excess basal insulin treatment. In our results, TBD was ~30% TDD, which was less than King's estimation. We assume that this is the result of the strict diabetic diet in the hospital setting. Diabetic meals are served to all patients. These meals are close to the macronutrient content as the meals recommended by the American Diabetes Association (6).

We consider that previous estimation (TBD = 0.5 × TDD) might have been influenced by several factors as follows. One is diet failure, i.e., increased fat intake. Fat ingestion may cause delay of gastric emptying, leading to late glucose excursion (7). When eating fat-rich pizza, it was recommended to give dual-wave bolus insulin for 8 h, which means giving bolus insulin for 8 h after normal bolus insulin to suppress late glucose excursion induced by fat (8). The basal insulin requirement in the daily life after discharge might be more than in the hospital if patients eat more fat than recommended. However, %TBD stayed at the same level without deteriorating glucose control 6 months after the study period. The other factor is the misunderstanding of blood glucose monitoring data in well controlled patients. There are some patients who set their basal insulin higher than required to lower their blood glucose. In these patients, although the peak glucose value is high, $HbA_{1c}$ is seemingly well controlled, which leads to the misunderstanding about their basal requirement.

We did not use a continuous glucose monitoring system (CGMS) in our study. Although there is a report showing that eight-point glucose testing a day is comparable to a continuous glucose monitoring system, eight-point glucose testing has the possibility of missing midnight hypoglycemia (9). In such a case, it might be better to further reduce the TBD. Furthermore, this study is of small size and is not designed to be a randomized study comparing different percentages of basal and bolus.

In conclusion, basal insulin requirement is ~30% TDD in Japanese type 1 diabetic patients who use the insulin pump.

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