Bolus Calculator Settings in Well-Controlled Type 1 Diabetes Patients (Glycated Hemoglobin <7%) Treated with Insulin Pumps

Bartłomiej Matejko, M.Sc.,[1] Małgorzata Grzanka, M.Sc.,[1] Beata Kieć-Wilk, M.D., Ph.D.,[1,2]
Maciej T. Małecki, M.D., Ph.D.,[1,2] and Tomasz Klupa, M.D., Ph.D.[1,2]

Two regimens of insulin therapy are used to achieve the goal of near normoglycemia: multiple daily injections (MDI) and continuous subcutaneous insulin infusion (CSII).[1] Due to the apparent improvement in quality of life and metabolic control and the greater personal independence (compared with MDI), CSII is becoming an increasingly popular method of insulin delivery for people with type 1 diabetes mellitus (T1DM).[1–3] However, one of the major problems related to the use of CSII, or intensive insulin regimens in general, is the accurate calculation of insulin boluses. These calculations should take into account multiple factors, such as current and target blood glucose levels, carbohydrate intake, insulin-to-carbohydrate ratio (ICR), and insulin sensitivity.[3] Using the ICR to calculate meal bolus and insulin sensitivity factor (ISF) to correct hyperglycemia are accepted methods of optimization of metabolic control.[3–5] These rules are also used to program the bolus calculator (BC), which is an insulin pump function.[3–6] The BC uses preprogrammed settings to generate a recommendation of bolus dose.[3] There is an agreement that these settings should be individualized for each person; however, some general rules as starting points do exist.[4–6] The aim of this analysis was to evaluate BC settings used by CSII-treated T1DM patients, exclusively with good metabolic control [glycated hemoglobin (HbA1c) < 7.0%].

Thirty-nine patients (26 females and 13 males) with T1DM treated with CSII and using a BC (more than 50% of total daily boluses delivered via this function) were included in this analysis. The data regarding body mass index (BMI), HbA1c level, diabetes duration, insulin dose, blood glucose parameters, and other clinical data from the past 3 years were collected from all the patients. Insulin pump memory data were downloaded via the Carelink software. Statistical analysis was performed with the use of statistical package Statistica10.0 PL. The Pearson or Spearman correlation was applied when appropriate. The mean age of the patients was 35 years, diabetes duration was slightly over 17 years, and mean HbA1c level was 6.38%. The clinical characteristics of the patients is summarized in **Table 1**. Mean ICR was 1.58 IU/10 g carbohydrates, and mean ISF was 36.8 mg/dl/IU of insulin. The ICR correlated positively ($r = 0.39$, $p = .013$; $r = 0.35$, $p = .032$) and the ISF negatively ($r = -0.57$, $p < .000$; $r = -0.41$, $p = .010$), with total daily insulin dose and daily insulin dose per kilogram of body weight. Additionally, ISF correlated negatively with BMI ($r = -0.34$, $p = .034$). No significant correlation was found between ICR or ISF and any of the following parameters: HbA1c, mean glycemia, diabetes duration, percentage of basal insulin, number of measurements per day, and age. The results of our study indicate that the rule for counting ICR (per 10 g of carbohydrate) in well-controlled T1DM patients should be approximately 290 and, for ISF, 1670.

Author Affiliations: [1]Department of Metabolic Diseases, Jagiellonian University Medical College, Krakow, Poland; and [2]University Hospital, Krakow, Poland

Abbreviation: (BC) bolus calculator, (BMI) body mass index, (CSII) continuous subcutaneous insulin infusion, (HbA1c) glycated hemoglobin, (ICR) insulin-to-carbohydrate ratio, (ISF) insulin sensitivity factor, (MDI) multiple daily injections, (T1DM) type 1 diabetes mellitus

Corresponding Author: Tomasz Klupa, M.D., Ph.D., Department of Metabolic Diseases, Jagiellonian University, 15 Kopernika St., 31-501 Kraków, Poland; email address *tomasz_klupa@yahoo.com*

Bolus Calculator Settings in Well-Controlled (Glycated Hemoglobin < 7%)
Type 1 Diabetes Patients Treated with Insulin Pumps

Matejko

Table 1.
Clinical Characteristics of Study Participants

Variable	Number of cases (n)	Variability Range (min-max)	Mean	Standard deviation	Median
HbA1c (%)	39	5.1–7	6.38	0.47	6.45
BMI (kg/m^2)	38	18.8–29.8	23.7	2.8	23.6
Daily insulin dose (IU)	39	23.7–76.4	45.5	13.3	43.5
Percentage of basal insulin (%)	39	22.3–54.7	39.7	7.4	39
Mean glycemia (mg/dl)	38	92–162	128.5	19.4	130
Number of daily boluses (n)	38	3.4–15.8	6.2	2.5	5.4
Insulin unit per kilogram body mass (IU/kg)	38	0.31–1.00	0.66	0.16	0.67
Dual bolus per day (n)	37	0–6.0	0.83	1.2	0.1
Age (years)	39	19–65	35.1	12.3	33
Diabetes duration (years)	39	2–38	17.3	9.6	17
Number of years on CSII (years)	37	0.5–10	3.7	2.6	3
Duration of insulin action in the BC (h)	39	3–6	3.5	0.6	3

In conclusion, we have shown that the ISF rule in Polish patients with good metabolic control is similar to rules used by other centers; however, the ICR rule should be much more stringent. We have also shown that the ISF rule should be considered with respect to patients' BMI.

References:

1. Bruttomesso D, Costa S, Baritussio A. Continuous subcutaneous insulin infusion (CSII) 30 years later: still the best option for insulin therapy. Diabetes Metab Res Rev. 2009;25(2):99–111.

2. EQuality1 Study Group--Evaluation of QUALITY of Life and Costs in Diabetes Type 1, Nicolucci A, Maione A, Franciosi M, Amoretti R, Busetto E, Capani F, Bruttomesso D, Di Bartolo P, Girelli A, Leonetti F, Morviducci L, Ponzi P, Vitacolonna E. Quality of life and treatment satisfaction in adults with Type 1 diabetes: a comparison between continuous subcutaneous insulin infusion and multiple daily injections. Diabet Med. 2008;25(2):213–20.

3. Klupa T, Benbenek-Klupa T, Malecki M, Szalecki M, Sieradzki J. Clinical usefulness of a bolus calculator in maintaining normoglycaemia in active professional patients with type 1 diabetes treated with continuous subcutaneous insulin infusion. J Int Med Res. 2008;36(5):1112–6.

4. Walsh J, Roberts R, Bailey T. Guidelines for insulin dosing in continuous subcutaneous insulin infusion using new formulas from a retrospective study of individuals with optimal glucose levels. J Diabetes Sci Technol. 2010;4(5):1174–81.

5. Walsh J, Roberts R, Bailey T. Guidelines for optimal bolus calculator settings in adults. J Diabetes Sci Technol. 2011;5(1):129–35.

6. King AB, Armstrong DU. A prospective evaluation of insulin dosing recommendations in patients with type 1 diabetes at near normal glucose control: bolus dosing. J Diabetes Sci Technol. 2007;1(1):42–6.