Carbohydrate Estimation Supported by the GoCARB System in Individuals With Type 1 Diabetes: A Randomized Prospective Pilot Study

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Accurate carbohydrate (CHO) counting to achieve satisfactory glucose control in type 1 diabetes (T1D) remains challenging in practice, and thus novel approaches are still needed (1,2). GoCARB is a computer vision-based application installed in a smartphone device that provides users with CHO content estimations from photos taken of plated meals (3). We present the results of a pilot prospective randomized controlled crossover study (NCT02546063) evaluating the effects of GoCARB on postprandial and overall glucose control in individuals with T1D using sensor-augmented insulin pump (SAP) therapy.

One week of GoCARB use was compared with conventional methods to estimate meal CHO content in 20 adults with T1D using SAP therapy (mean age 35 ± 14 years, BMI 25.5 ± 3.8 kg/m^2, HbA_{1c} 7.5 ± 0.6% [58.7 ± 5.9 mmol/mol], duration of diabetes 17 ± 10 years, duration of SAP use 2.7 ± 1.7 years, 13 men and 7 women). Prerandomization, each participant underwent a 2-week familiarization with the training version of the GoCARB software (without automated CHO output).

A detailed description of the system has been presented previously (4). In brief, the application requires users to take two subsequent photos of a plated meal with a reference card placed next to it. The application then generates the CHO content based on volumetric assessment of food components on the plate, referenced against a nutritional database. During the GoCARB intervention period, the application provided

Table 1—CGM and insulin end points

	GoCARB group (n = 20)	Control group (n = 20)	P value
% Time hyperglycemic (>12 mmol/L)	15.0 ± 2.0	18.2 ± 2.1	0.039
% Time hypoglycemic (<3.5 mmol/L)	2.3 ± 0.8	2.6 ± 0.7	0.58
% Time in target (3.9–10 mmol/L)	65.9 ± 2.7	63.2 ± 2.8	0.19
180-min postprandial iAUC (mmol/L/min)	205.9 ± 29.3	269.9 ± 39.8	0.13
Mean glucose (mmol/L)	8.7 ± 0.3	8.9 ± 0.3	0.15
Glucose standard deviation (mmol/L)	3.0 ± 0.1	3.2 ± 0.2	0.007
Daily bolus insulin (units/24 h)	27.5 ± 2.3	30.0 ± 2.3	0.11
Number of boluses (n/24 h)	6.8 ± 0.4	7.3 ± 0.5	0.12
Total daily insulin (units/24 h)	47.5 ± 3.2	50.0 ± 3.2	0.14

Data presented as mean ± SEM. iAUC, incremental area under the sensor glucose curve.

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automated CHO suggestion. Individual meal insulin bolusing was at the patient's own discretion. A real-time continuous glucose monitoring (CGM) device was worn during both study periods. Analysis was per intention-to-treat.

CGM and insulin end points are shown in Table 1. GoCARB significantly reduced proportion of time spent hyperglycemic (>12 mmol/L, $P = 0.039$) and glycemic variability (measured as standard deviation of sensor glucose, $P = 0.007$), with similar time spent hypoglycemic ($P = 0.58$). Total daily insulin dose and number of insulin boluses per day were comparable ($P = 0.14$ and $P = 0.12$, respectively).

We showed for the first time in a randomized crossover design study the feasibility of a novel automated CHO-estimation approach, with improvements in both proportion of time spent hyperglycemic and glucose variability as measured by sensor glucose. Automation of CHO estimation may, therefore, improve glucose control and help support daily T1D self-management. Of note, postprandial glucose excursions did not significantly differ in the current study. This may be partly due to the relatively short duration and limited sample size of this pilot study. Also, the postprandial period defined a priori in this study may not have accounted for the delayed glucose excursions caused by other macronutrients, such fat and protein (5). Post hoc analysis revealed that use of the application was most frequent at lunch and dinner. This may have been related to the restriction of GoCARB use to plated meals. The study consisted of T1D patients who were trained in CHO counting, thereby limiting its generalizability to the wider population. Longer and larger studies are still needed, inclusive of a broader T1D population, to validate our findings and assess the impact of GoCARB on the burden of self-management and quality of life.

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