



Low–Blood Glucose Avoidance Training Improves Glycemic Variability in Adults With Type 1 Diabetes Complicated by Impaired Awareness of Hypoglycemia: HypoCOMPASS Trial

Diabetes Care 2016;39:e56–e58 | DOI: 10.2337/dc15-2431

Hong Kai Tan,¹ Stuart A. Little,²
Lalantha Leelarathna,³
Emma Walkinshaw,⁴
Alexandra Lubina-Solomon,⁴
Joanne Hosking,⁵ Jane Speight,^{6,7,8}
David Kerr,⁹ Simon R. Heller,⁴
Mark L. Evans,³ James A.M. Shaw,²
and Daniel Flanagan¹

The Comparison of Optimized MDI Versus Pumps With or Without Sensors in Severe Hypoglycemia (HypoCOMPASS) trial was a prospective, multicenter, randomized controlled trial examining the restoration of impaired awareness of hypoglycemia (IAH) and the prevention of severe hypoglycemia (SH) in adults with type 1 diabetes using multiple daily injections (MDI) compared with continuous subcutaneous insulin infusion (CSII), with or without adjunctive real-time continuous glucose monitoring (RT-CGM), using a 2 × 2 factorial design (1). Few studies are currently available to compare the difference in glucose variability (GV) between MDI and CSII and between self-monitored blood glucose (SMBG) and RT-CGM (2–4). These studies showed an improvement in GV in favor of CSII and RT-CGM. However, none of them included participants with IAH or history of SH. The aim of this study is to compare the changes in GV between MDI and CSII and between SMBG and RT-CGM group in this specific patient group

with type 1 diabetes with IAH or recurrent SH.

A total of 96 participants were recruited for the study. Each participant undertook 7 days of blinded CGM using Medtronic iPro at baseline and prior to each of the four weekly visits during the 24-week randomized controlled trial period. GV was measured as glucose SD and coefficient of variation (%CV), calculated using available Excel formulas published online (5).

Overall, there were decreases in GV between baseline and week 24 measured by SD (3.9 ± 1.0 vs. 3.4 ± 0.8 mmol/L, $P < 0.001$) and %CV (41.3 ± 8.0 vs. $36.8 \pm 8.1\%$, $P < 0.001$).

The MDI group realized improvement in GV from baseline to week 24 as measured by SD (3.8 ± 1.0 vs. 3.3 ± 0.7 mmol/L, $P = 0.007$) and %CV (42.1 ± 8.4 vs. $36.1 \pm 6.7\%$, $P = 0.002$). The CSII group realized similar improvement in SD (4.0 ± 1.0 vs. 3.5 ± 0.8 mmol/L, $P = 0.005$) and %CV (41.7 ± 7.2 vs. $37.5 \pm 9.2\%$, $P = 0.01$). Thus, CSII and MDI therapy did not differ in SD and %CV at baseline and week 24.

However, using mixed-effects modeling, taking into account GV at each time point and other covariates, CSII appeared to have a more rapid impact in GV improvement compared with MDI, with an estimated average difference of $-3.25 \pm 0.96\%$ (95% CI $-5.15, -1.36$) ($P = 0.001$) in %CV and a trend toward improvement in SD with difference of -0.25 ± 0.13 mmol/L (95% CI $-0.50, 0.002$) ($P = 0.052$) (Fig. 1).

The SMBG group realized GV improvement in %CV between baseline and week 24 (41.3 ± 6.9 vs. $37.1 \pm 6.5\%$, $P = 0.005$). No differences were seen in SD (3.8 ± 0.9 vs. 3.5 ± 0.7 mmol/L, $P = 0.069$). In the RT-CGM group, GV improvement was seen in both SD (4.0 ± 1.0 vs. 3.4 ± 0.8 mmol/L, $P < 0.001$) and %CV (42.4 ± 8.5 vs. $36.8 \pm 9.4\%$, $P = 0.003$). SMBG and RT-CGM groups did not differ at baseline and week 24. Further, these groups did not differ when GV was analyzed using mixed-effects modeling (Fig. 1).

These data suggest that the educational intervention has played an important part

¹Derriford Hospital, Plymouth, U.K.

²Institute of Cellular Medicine, Newcastle University, Newcastle, U.K.

³Wellcome Trust-MRC Institute of Metabolic Science Metabolic Research Laboratories, University of Cambridge, Cambridge, U.K.

⁴School of Medicine and Biomedical Sciences, The University of Sheffield, Sheffield, U.K.

⁵Plymouth University Peninsula Schools of Medicine and Dentistry, Plymouth, U.K.

⁶AHP Research, Hornchurch, U.K.

⁷Australian Centre for Behavioural Research in Diabetes, Melbourne, Australia

⁸Centre for Mental Health and Wellbeing Research, School of Psychology, Deakin University, Burwood, Australia

⁹Bournemouth Diabetes and Endocrine Centre, Royal Bournemouth Hospital, Bournemouth, U.K.

Corresponding author: Daniel Flanagan, danielflanagan@nhs.net.

Received 9 November 2015 and accepted 19 January 2016.

Clinical trial reg. nos. ISRCTN52164803, www.controlled-trials.com, and 2009-015396-27, www.clinicaltrialsregister.eu.

A complete list of the members of the HypoCOMPASS Study Group can be found in the APPENDIX.

© 2016 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered.

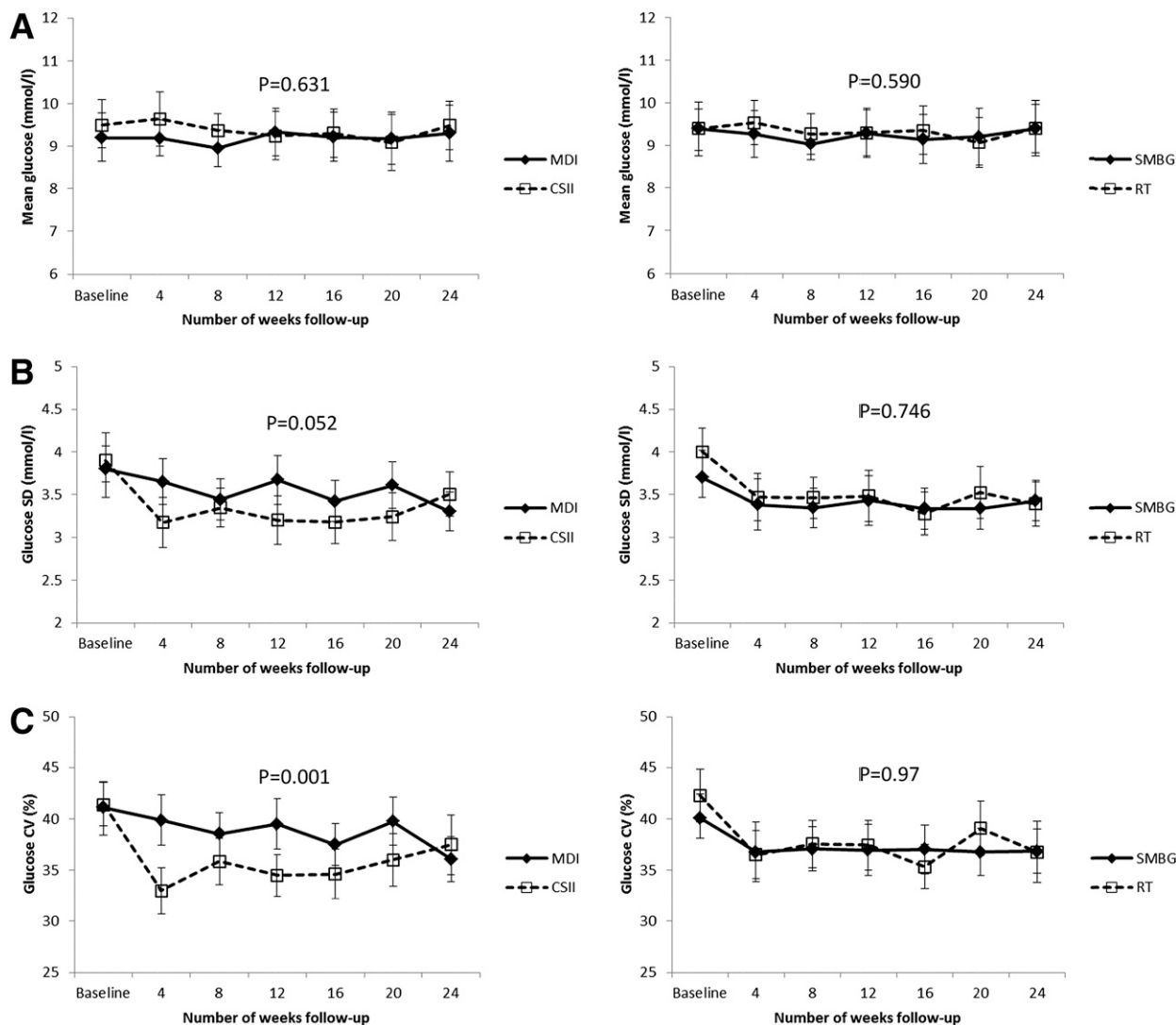


Figure 1—Glucose variability over time (mean, 95% CI) according to insulin comparator group (left) and monitoring comparator group (right). The difference between groups was established using mixed-effects models, taking into account data at all time points. A: Mean glucose (mmol/L). B: Glucose SD (mmol/L). C: Glucose CV (%). RT, RT-CGM.

in improving GV, although there was no specific control group to support this hypothesis.

In conclusion, we have shown that GV can be improved within 24 weeks in adults with long-standing type 1 diabetes complicated by IAH and recurrent SH. This was seen in all four arms of the study, suggesting that the education-based intervention coupled with weekly health care professional input was essential.

Acknowledgments. The authors thank study participants and staff at all participating sites. The authors thank Dr. Pratik Choudhary, King's College London, for his advice on CGM analysis.

Funding. The study was funded by Diabetes UK (07/0003556).

Duality of Interest. No pharmaceutical company or medical device manufacturer has had any role in the design or funding of this trial. J.S. is a member of the Accu-Chek Advisory Board (Roche Diagnostics Australia). Her research group has received unrestricted educational grants from Medtronic and Sanofi Diabetes; sponsorship to host or attend educational meetings from Lilly, Medtronic, MSD, Novo Nordisk, Roche Diagnostics Australia, and Sanofi Diabetes; and consultancy income from Roche Diagnostics Australia and Sanofi Diabetes. D.K. has received honoraria for participation in educational events and consultancy fees from Abbott Diabetes Care, manufacturers of glucose sensors. S.R.H. has carried out consultancy work for pump/meter insulin companies, LifeScan, Sanofi, Novo Nordisk, and Lilly; has received research support from Medtronic; and has received speakers' fees from Novo Nordisk, Lilly,

and LifeScan. M.L.E. has received travel support from Roche and Medtronic; has received support for studies from Roche, Medtronic, and Abbott Diabetes Care; sits on advisory boards for Medtronic, Roche, and Cellnovo; and has received speakers' fees from Animas. J.A.M.S. has taken part in medical advisory boards for Novo Nordisk, Sanofi, Johnson & Johnson, and Medtronic, receiving travel support for conference attendance, and has received grant funding from Medtronic, Novo Nordisk, and Sanofi. D.F. has received speakers' fees from Animas and Novo Nordisk. No other potential conflicts of interest relevant to this article were reported.

Author Contributions. H.K.T. and D.F. wrote the first draft of the manuscript. H.K.T., S.A.L., L.L., E.W., and A.L.-S. contributed to the collection and review of the study data. Statistical analysis was undertaken by J.H. All authors reviewed and commented on various versions of the manuscript. D.F. is the guarantor of this

work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Prior Presentation. An abstract containing some of the reported data was presented at the Diabetes UK Professional Conference, London, U.K., 11–13 March 2015.

Appendix

HypoCOMPaSS Study Group. AHP Research: S.M. Barendse, C.V. McMillan, and J. Speight; Bournemouth: J. Begley, A. Bowes, O. Chapple, D. Kerr, and M. Nation; Cambridge: H. Brown, K. Davenport, M.L. Evans, S. Hartnell, L. Leelarathna, C. Riches, and C. Ward; Newcastle: C. Brennan, C. Gordon, A. Lane, S.A. Little, S.M. Marshall, J.A.M. Shaw, J. Stickland, L. Thompson, and R. Wood; Sheffield: M. Cunningham, S.R. Heller, S. Hudson, A. Lubina-Solomon, C. Nisbet, and

E. Walkinshaw; Plymouth: D. Flanagan, S. Read, and H.K. Tan.

Trial Steering Committee. S.A. Amiel (chair), J. Begley, C. Brennan, T. Chadwick, E. Davidson, M.L. Evans, D. Flanagan, L. Hall, S.R. Heller, V. King, S.A. Little, C. Littlewood, J. Matthews, J.A.M. Shaw, C. Speed, J. Speight, and R. Wood.

References

1. Little SA, Leelarathna L, Walkinshaw E, et al. Recovery of hypoglycemia awareness in long-standing type 1 diabetes: a multicenter 2×2 factorial randomized controlled trial comparing insulin pump with multiple daily injections and continuous with conventional glucose self-monitoring (HypoCOMPaSS). *Diabetes Care* 2014; 37:2114–2122
2. Prieto-Tenreiro A, Villar-Taibo R, Pazos-Couselo M, González-Rodríguez M, Casanueva F, García-López JM. Benefits of subcutaneous

continuous insulin infusion in type 1 diabetic patients with high glycemic variability. *Endocrinol Nutr* 2012;59:246–253 [in Spanish]

3. Chimenti EM, de la Morena LH, Vaquero PM, Sáez-de-Ibarra L, Domínguez MG, Sánchez LF. Assessing glycaemic variability with continuous glucose monitoring system before and after continuous subcutaneous insulin infusion in people with type 1 diabetes. *Diabetes Res Clin Pract* 2010;90:e57–e59

4. Garg SK, Voelmlle MK, Beatson CR, et al. Use of continuous glucose monitoring in subjects with type 1 diabetes on multiple daily injections versus continuous subcutaneous insulin infusion therapy: a prospective 6-month study. *Diabetes Care* 2011;34:574–579

5. Rodbard D. New and improved methods to characterize glycemic variability using continuous glucose monitoring. *Diabetes Technol Ther* 2009;11:551–565