Glucose Control Using a Standard vs an Enhanced Hybrid Closed Loop System: A Pilot Study

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Introduction

- Previous studies indicate that closed loop systems are effective and safe in improving glucose control among adolescents and adults with type 1 diabetes (T1D). They result in improved sensor glucose target range and reduce hypoglycaemia when compared with standard therapy.^{1,2}
- The MiniMed 670G system (Medtronic, Northridge, CA) is the first commercially available hybrid closed loop (HCL) insulin delivery system. It utilises an e-PID algorithm with insulin feedback.³
- Insights gained from trials and clinical use have informed iterative modifications to the standard-HCL system resulting in a prototype enhanced-HCL system.
- The enhanced-HCL algorithm incorporates enhanced correction insulin bolus reminders and modifications broadening glucose and insulin delivery parameters, with the aim of remaining in CL for longer periods and an ultimate goal of improving glucose control.

Aim

To compare glucose control, closed loop exits and alarm frequency with standard-HCL vs enhanced-HCL systems.

Methods

- Eleven pump-experienced T1D adults were assigned standard-HCL and enhanced-HCL systems in random order for 1-week each (and 1 week washout between stages), undertaken in a supervised live-in setting (hotel).
- For both standard-HCL and enhanced-HCL stages, insulin delivery was via a Medtronic pump with identical interventions designed to challenge glucose control and persistence in CL.
- Challenges included: two missed meal boluses; two high-GI and two high-fat meals (breakfasts and dinners) and a 40-minute bout of moderate-intensity exercise. Challenges were separated by at least 8-hours.
- The primary outcome was continuous glucose monitoring (CGM) sensor time in target range (3.9-10 mmol/L).

FIGURE 2: Study overview

Results

TABLE 1: Clinical characteristics of participants

Baseline variable	Mean [standard deviation]
Mean age (years)	51 [15]
Diabetes duration (years)	26.4 [7.7]
HbA1c (% or mmol/mol)	7.5 [1.0] or 58 [7.7]

TABLE 2: Results

	Standard HCL (n=11)	Enhanced HCL (n=11)	p
Insulin delivery and settings			
Total daily insulin (units)	44 (18)	47 (24)	N/A
Basal insulin proportion (%)	55 (8)	55 (7)	N/A
Bolus insulin proportion (%)	45 (8)	45 (7)	N/A
Insulin-to-carbohydrate ratio	9.6 (3.1)	9.6 (3.1)	N/A
Insulin action time (h)	3.7 (0.6)	3.7 (0.6)	N/A
Glucose metrics			
Time in 3.9-10 mmol/L (%)	69 (11)	74 (10)	0.15
Mean sensor glucose (mmol/L)	8.9 (0.7)	8.4 (0.6)	0.09
Time < 3.9 mmol/L (%)	1.9 (2.4)	1.2 (1.2)	0.42
Time < 2.8 mmol/L (%)	0.4 (0.5)	0.2 (0.3)	0.21
Time > 10 mmol/L (%)	29 (11)	24 (9)	0.37
Time > 13.9 mmol/L (%)	7.3 (5.6)	6.1 (4.7)	0.48
Algorithm-related alerts and dropouts			
Alerts (n / week)	8.6 (5.8)	3.9 (2.8)	0.01
CL exits (n / week)	3.5 (3.1)	0 (0.0)	0.004
Time in CL (% / week)	96.9 (5.1)	98.5 (0.8)	0.23

*All results are mean (SD); N/A = not applicable

FIGURE 1: Hybrid Closed Loop System

Results

- Enhanced-HCL resulted in significantly fewer CL alerts and CL exits than standard-HCL
- Differences in time in target range, mean glucose and time in closed loop (approximately 3 hours over 1 week) favoured enhanced-HCL but did not reach statistical significance though it should be recognised that this was an exploratory study not powered to detect a difference.
- No episodes of severe hypoglycaemia or ketoacidosis occurred.
- Participants underwent standardised interviews at study completion, all expressed a preference for the enhanced-HCL over the standard-HCL system due to improved user interface and reduced alerts and exits from CL.

Conclusion

- The standard-HCL system has previously demonstrated significant improvements in glucose control among people with T1D; this study shows that further refinement is possible.
- A limitation of this protocol is that with multiple glycaemic challenges during 1-week in a supervised setting, the study does not reflect the everyday experience of a person with T1D. Therefore, the mean sensor glucose outcomes measured are not directly comparable with other CL studies.
- These preliminary data demonstrate safety, significantly reduced CL exits and alerts, user preference for enhanced-HCL over standard-HCL, and a trend towards improved glucose control with enhanced-HCL in an adult group.
- Longer term home-based studies more reflective of usual care are merited to confirm these findings.

References

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