

Comparison of Automated Insulin Delivery (AID) Systems

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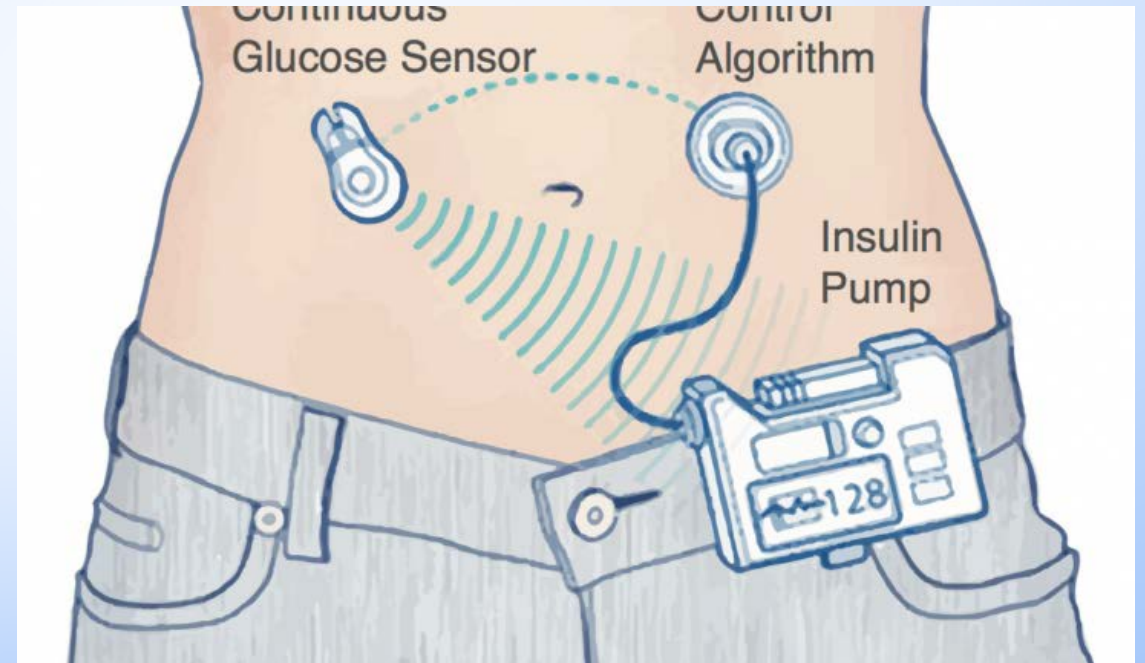
With thanks to

John Pemberton RD,

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To discuss

- The different systems currently commercially available
- How the algorithms work
- Key tips for onboarding and education



Hybrid Closed Loop Systems



Medtronic 780 G



Cam APS

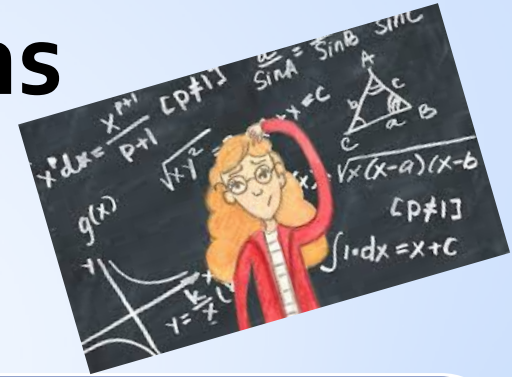


Tandem Control iQ



Omnipod 5

Closed loop system algorithms



Model predictive control

predict future glucose to bring current glucose into the target range

Control IQ, CamAPS FX, Omnipod 5

Proportional integral derivative

analyses deviation of measured glucose from target glucose to calculate the amount of insulin to deliver

Medtronic 780G

Fuzzy logic

calculate insulin doses based on how a clinical expert would make real-time adjustments based on CGM data

How does Medtronic 780G work?



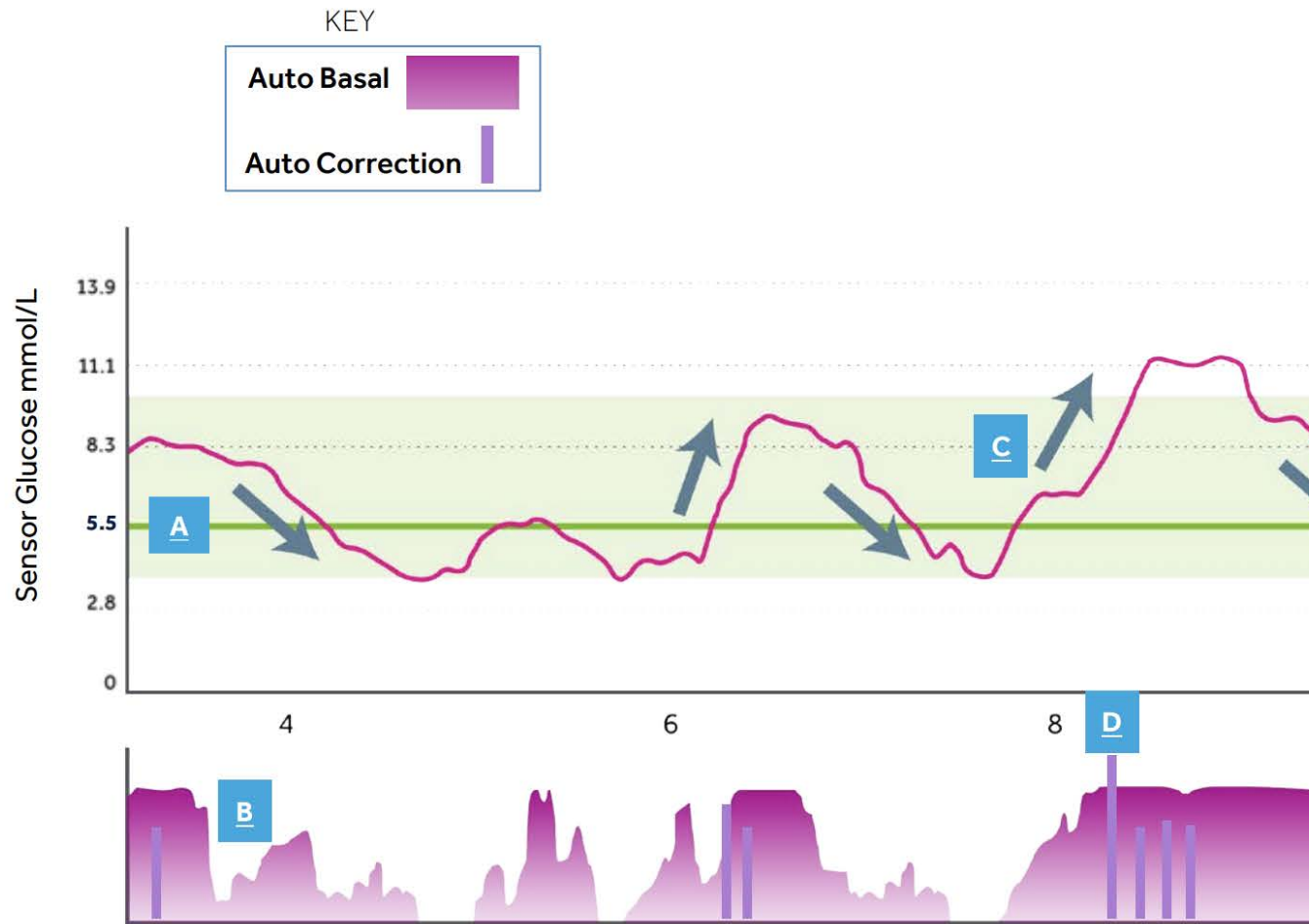
- Algorithm does not use manual set basal rates, so changing basal rates will not impact Auto Mode
- ↓ basal insulin when sensor glucose is falling below target
- ↑ basal insulin when sensor glucose is rising above target
- Delivers auto bolus when basal reached, and SG > 6.7 mmol/l

Algorithm uses real-time information to adjust basal every 5 mins aiming for target:

Current SG, How far SG is from the set target, How long SG has been away from target, How rapidly SG has been changing
Estimated total insulin (Basal and Bolus)

Algorithm uses TDD to calculate

- ISF (updated every midnight)
- Max and Min autobasal (updated every 6-12 days)



SUMMARY

- A** Selection between the default setting of 5.5 mmol/L, and 6.1 mmol/L or 6.7 mmol/L.
- B** Basal insulin adjusts every 5 mins based on SG values
- C** The auto correction target is set at 6.7 mmol/L
- D** Auto corrections delivered every 5 minutes if max basal reached and SG is above 6.7 mmol/L, as determined by the algorithm. NO automatic corrections if Temp Target is set.

How does Control-IQ work?



- **Uses programmed basal rates** to modulate up and down. (Adjusting these at reviews will help improve how it works.)
- Control IQ Algorithm uses weight, insulin sensitivity from personal profile and the current glucose level, trend and IOB.
- How insulin is adjusted depends on 10 min predicted BG treatment values (*see next slide*)
- Manually set basal rate up and down every 5 minutes according to calculations aiming for a glucose level between 6.3-8.9mmol/l.
- Glucose target is set to 6.1mmol/l for boluses and AIT set at 5 hours

How does Control-IQ modulate insulin?

≥ 10.0 mmol/l

- Delivers auto-correction bolus (60% expected -IOB per hour) if SG is predicted to be > 10 mmol/l

≥ 8.9 mmol/l

- \uparrow basal insulin if SG is predicted to be > 8.9 mmol/l

6.25-8.9 mmol/l

- Maintains personal profile settings

≤ 6.25 mmol/l

- \downarrow basal insulin if SG is predicted to be < 6.3 mmol/l

≤ 3.9 mmol/l

- Stops insulin delivery if SG is predicted to drop < 3.9 mmol/l

Always targets to 6.1.

How does CAMAPS FX work?

Most complex algorithm

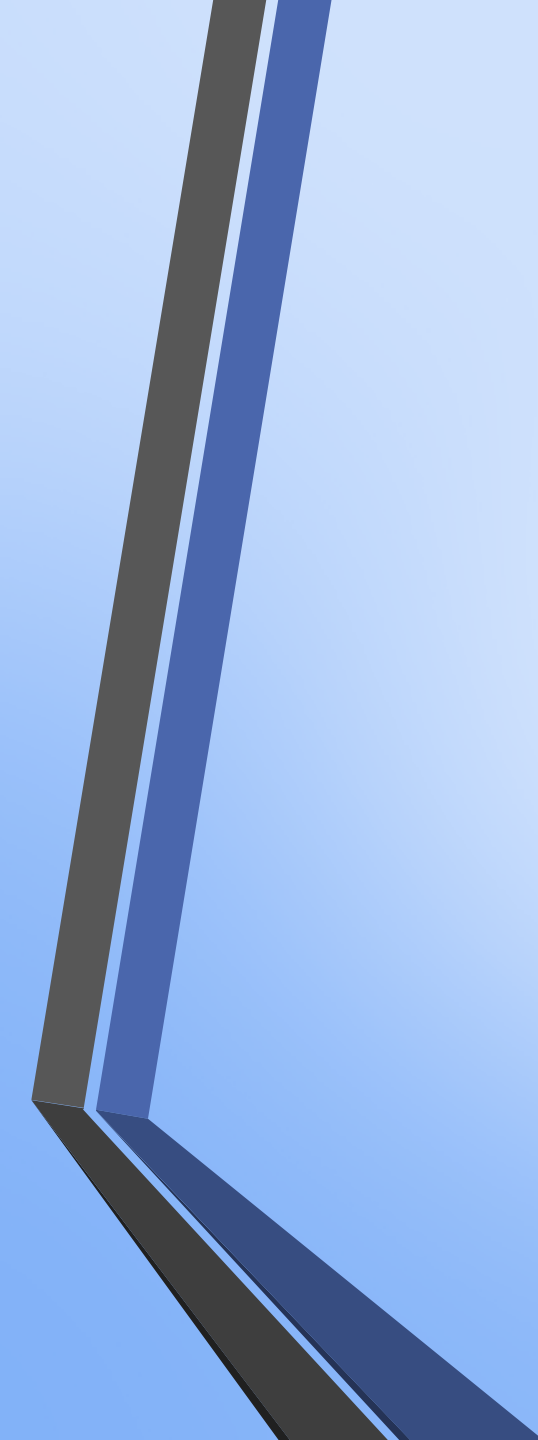
- Predicts glucose over the next 2.5 – 4 hours
- Prediction is based on past insulin and glucose data and parameters which feed into algorithm (AIT, ISF, CHO intake)
- System has a number of different scenarios to modify future insulin delivery
- Selects the scenario which it predicts will lead to desired glucose trajectory
- Calculates insulin dose and delivers basal as extended bolus every 10-12 mins
- Adjustable Personal Glucose Target
- Algorithm uses body weight, TDD from last 5 days, learned insulin needs from previous days, current glucose level/trend & carbs on board



How does Omnipod 5 HCL work?



- SmartAdjust algorithm
- Predicts where SG will be in 60 mins and adjusts insulin delivery every 5 mins
- Basal delivered as microboluses every 5 mins
- Customisable target 6.1-8.3 mmol/l
- Smart bolus calculator (\uparrow or \downarrow suggested bolus based on CGM level and trend arrow and can \downarrow suggested bolus based on IOB)
- ICR & ISF used for boluses but ISF not used for algorithm
- With each new Pod activation, the system adapts insulin delivery based on physiological needs and TDD (creates an 'adaptive basal rate')
- When out of loop will deliver whichever is lowest from programmed basal OR ABR



Comparison of currently available HCL systems

HCL system	Smartguard	Tandem Control IQ	CamAPS FX	Omnipod 5
Pump	Medtronic 780G	Tandem T: Slim	Dana RS/Dana I Ypsomed compatible pump	Omnipod 5 (with OP5 handset)
CGM	Medtronic Guardian3 and 4	Dexcom G6	Dexcom G6/Libre 3	Dexcom G6 (with own phone and Clarity App)
License	7-80 years TDD 8-250 units/day Weight 10-300kg Rapid acting insulins	> 6 years TDD 10—100 units/day Weight 25-140kg Rapid acting insulins	>1 year Pregnancy TDD 5-350 units/day Weight 10-300kg Rapid & ultra rapid insulins	> 2 years TDD 5u – 200u/d (to get 3 day pod wear) Rapid acting insulins
Parameters for AID	Uses TDD from last 2-6 days to calculate algorithm parameters Ongoing adjustment	Personal profile (basal rates/ICR/ISF) Uses weight and TDD input by user to determine algorithm parameters	Uses weight and TDD input by user to determine algorithm parameters Ongoing learning	Target glucose is only factor affecting insulin delivery. Aggressiveness of algorithm is learnt from TDD history of previous 4-5 pods
Basal insulin	Basal insulin adjusted every 5 mins	Basal insulin adjusted if SG predicted to exit target range	Extended boluses given every 10-12 mins	Adaptive basal rate given as microboluses every 5 mins
Autocorrections	If SG>6.7mmol/l and max auto-basal	If SG predicted > 10mmol/l, 60% correction bolus, 1 per hour	Automatic correction boluses delivered as modulation of basal rate	Automatic correction boluses delivered as modulation of basal rate

HCL system	Smartguard	Tandem Control IQ	CamAPS FX	Omnipod 5
Bolus	Manual bolus No Extended boluses Uses programmed ICR	Manual bolus Extended bolus possible for 2hrs Uses programmed ICR & ISF	Remote bolus (phone app) No Extended boluses Uses programmed ICR	Remote bolus (handset) SmartBolus feature accounts for glucose AND TREND <i>Ensure reverse correction is on</i> No extended boluses Uses programmed ICR and ISF
Target	Default 5.5 mmol/l 6.1 or 6.7 mmol/l	6.25-8.9 mmol/l	Personalised target 4.4 - 11.0 mmol/l Default 5.8 mmol/l Variable targets across 24 hrs	Personalised target 6.1-8.3mmol/l in up to 8 time segments
Adjustable parameters that affect algorithm	ICR, AIT Target glucose	Basal profiles, ICR, ISF, weight Target glucose	ICR, weight, add meals Target glucose	Target glucose, AIT ICR & ISF (for meals)
Overrides	Temp target 8.3 mmol/l	Exercise 7.8-8.9 mmol/l Sleep target – 6.36-6.7 mmol/l & no autocorrections	Ease off – reduces delivery by ~ a third Boost – increases delivery	Activity – raised target to 8.3, reduces insulin deliver and limits microbolus corrections
Reverts to manual mode	Loss of CGM data Sensor integrity concerns Max basal limit reached	Loss of CGM data Max insulin delivery reached	Loss of CGM data Loss of connection with pump	Loss of CGM data/warm up – Max deliver reached In LIMITED mode will deliver programmed basal OR learnt basal – whichever is lowest.

Quirks of the systems

HCL system	Smartguard	Tandem Control IQ	CamAPS FX	Omnipod 5
Onboarding	Needs 48hrs in open loop before SmartGuard on Do not turn on pump out of box until ready to use Active Insulin: 2 hours aggressive/2 ½ hours normal/3 hours safe Set target at 5.5mmol/L	May need stronger ICRs & ISFs due to higher target and longer AIT	Previous settings should be OK Use Target 5.5 unless under 5s or high HbA1c then start higher	May need stronger ICRs & ISFs due to higher target
Rapid changes in activity levels/insulin needs	More active – raise PGT Less active/sick – lower PGT	Create second profile with stronger/weaker settings	More active – raise PGT Less active/sick – lower PGT	More active – raise PGT Less active/sick – lower PGT
Exercise	Temp target 60-90 ins before and before meal if eating in this time. Reduce meal bolus by 20%	Activity mode 60-90 ins before and before meal if eating in this time. Reduce meal bolus by 20% Cannot set time – remember to turn off	Ease off 60-90 ins before and before meal if eating in this time. Reduce meal bolus by 20%	Activity mode 60-90 ins before and before meal if eating in this time. Reduce meal bolus by 20%
Food - Missed boluses - HFHP	Most likely system to manage missed boluses/HFHP - Leave it	Half carbs if remember within 60 mins, or push a correction using glucose reading. HFHP – extend	Add meal option for HFHP (complicated!)	Half carbs if remember within 60 mins, or push a correction using glucose reading. HFHP – leave it

Top tips for getting the most of HCL systems

- Pre-bolus for food by 10-15 mins
- Announce exercise
- Suspend insulin if removing pump
- Keep sensor accurate and connected
- Change cannula on schedule and keep sites healthy
- Respond to alerts/alarms
- Notice when out of loop and do what is needed to get back in
(calibrate, reenter automode on Omnipod from limited mode)



All are spectacular.....

They simply cater for different tastes

