Technology Update 2017

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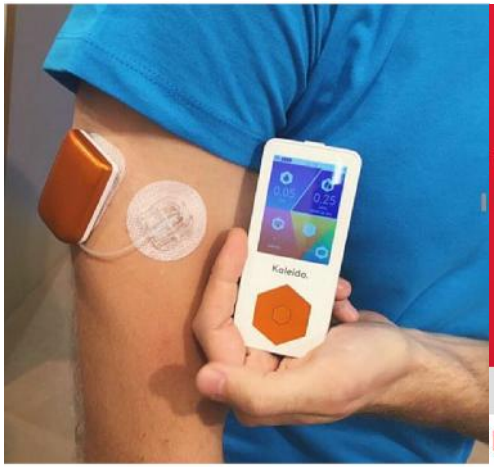
	Roche Insight	Animas Vibe*	Medtronic 640G*	Omnipod patch pump	Cellnovo patch pump	Kaleido patch pump
Pump features						
Weight	122 g	105 g	96 g	25 g	30 g	19 g
Basal increment	0.01 U (0.02-25)	0.025 U (0.025-25)	0.025 U (0.025-35)	0.05 U (0.05-30)	0.05 U (0.05-30)	0.05 U (0.05-5)
Basal rate/d	24	12	48	24 @ 30 min	24	24
Basal profiles	5	4	8	7	20	7
Basal deliver	3 min	3 min	10m (0.2-60)	0.05 u pulse	?0.05 u pulse	?0.05 u pulse
Extended bolus	15 min steps up to 24 h	30 min steps up to 12 h	30 min steps up to 8 h	30 min steps up to 8 h	30 min steps up to 8 h	30 min steps up to 3 h
Bolus increments	0.05 U (max 25)	0.05 U (max 35)	0.1 U (max 75)	0.05 U (max 30)	0.05 U (max 30)	0.05 U (max 20)
Occlusion alarm	< 2h	1.5-3h	2-3.8h	?	Max 16h	?
Insulin vol	160 u	200 u	300 u	200 u	170 u	200 u

*Sensor augmentation option

New pumps



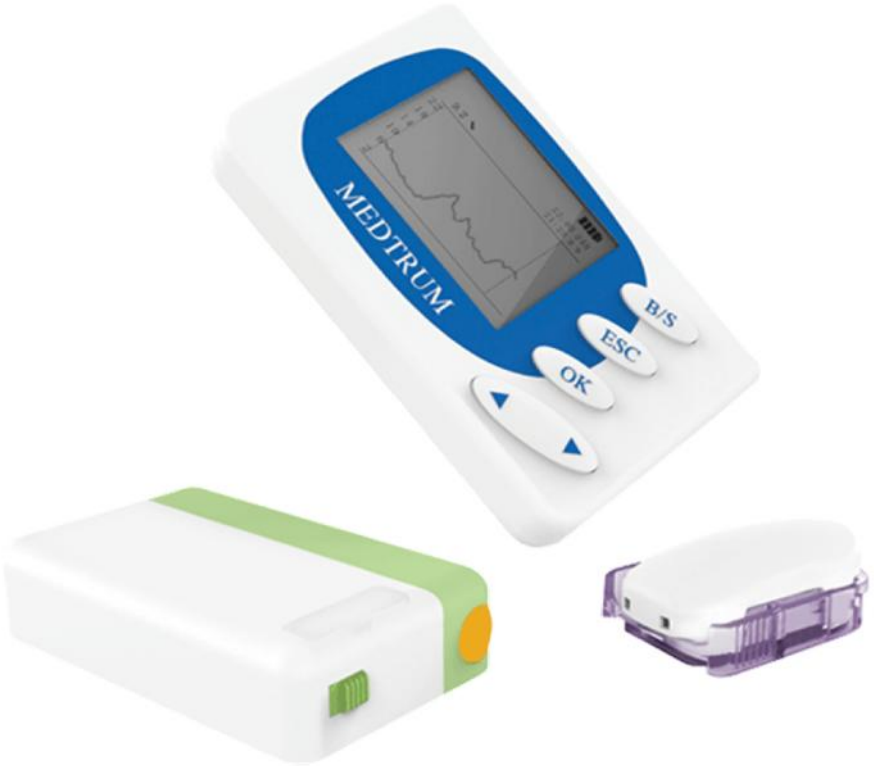

Want to see how your Kaleido pumps and handset could look? Just click on any of the colours below for a sneak peek!


YpsoPump
160U
Compatible with
NovoRapid® PumpCart®

Kaleido “pulse technology”

- Claim much better accuracy of insulin delivery than other pumps
- Rapid identification of blockages – state of the art optical sensor

Medtrum “semi-closed loop”



- Disposable patch-pump
  - Designed specifically for the treatment of T2 and GDM(?)
- Disposable CGM, 7 day
- PDM
- PLGS

REPOSE: DAFNE ± CSII

- Reduced incidence severe hypoglycaemia in both arms
- CSII improved treatment satisfaction, dietary freedom and daily hassle

Conclusions

People with type 1 diabetes might be better served by ensuring far greater availability of high quality, structured self management training, which is currently only accessed by around 10% of adults in the UK.[22] Participants might only recognise the limitations of insulin delivery by multiple daily injections if they start actively managing their diabetes after training. Those individuals could then be offered pump treatment to help them reach the stringent glucose targets necessary to achieve an HbA1c of 6.5% or to overcome problematic hypoglycaemia.

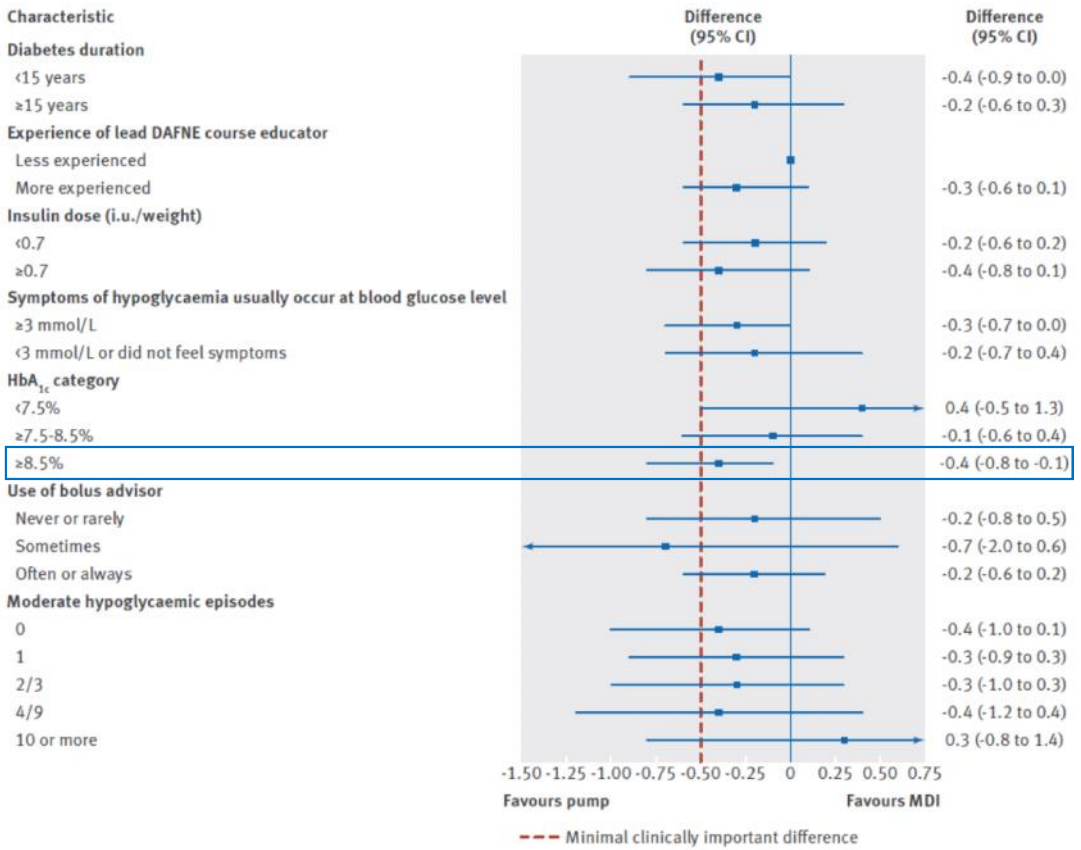
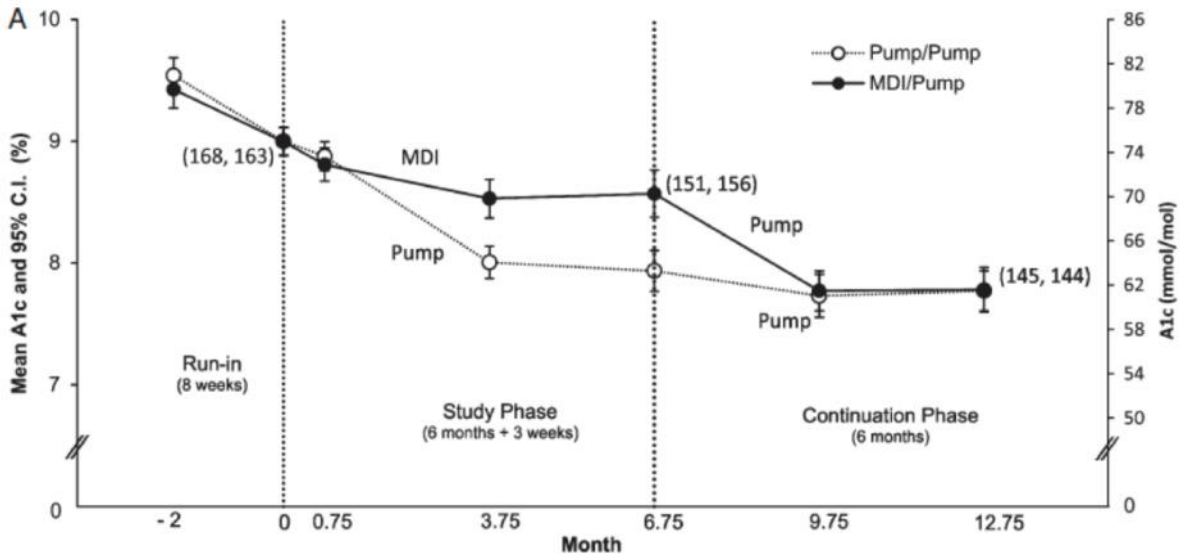
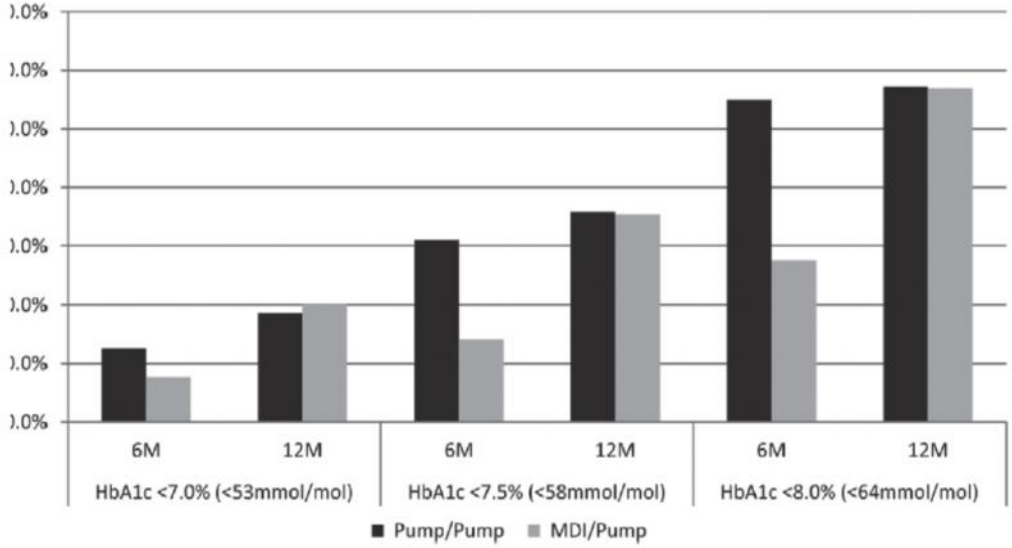


Fig 4 | Mean difference in HbA1c change (%) at 24 months by subgroup

The REPOSE study group *BMJ* 2017;356:j1285

OpT2mise extension





Aronson R et al. *Diabetes Obes Metab* 2016;18:500-7

CSII in T2DM: longterm control

Mean HbA1c at baseline 9.0±1.7%; Mean insulin dose 1.2±0.9 u/kg

Table 1—Outcomes of CSII during 9-year follow-up

	Duration of insulin pump therapy (years)								
	1	2	3	4	5	6	7	8	9
Number of patients	161	122	105	85	70	57	37	23	17
Decrease in HbA_{1c} from baseline (% [mmol/mol])	−1.3 ± 1.8 (14.2 ± 19.7)	−1.3 ± 1.9 (14.2 ± 20.8)	−1.3 ± 1.7 (14.2 ± 18.6)	−1.4 ± 2.0 (15.3 ± 21.9)	−1.5 ± 1.9 (16.4 ± 20.8)	−1.0 ± 2.0 (10.9 ± 21.9)	−1.6 ± 2.0 (17.5 ± 21.9)	−1.5 ± 2.1 (16.4 ± 23.0)	−1.4 ± 2.1 (15.3 ± 23.0)
Mean increase in weight from baseline (kg)	2.9 ± 7.6	3.7 ± 8.1	3.8 ± 8.9	4.8 ± 9.8	4.0 ± 10.9	6.1 ± 11.0	2.9 ± 10.4	8.7 ± 10.1	7.6 ± 11.0
Total daily insulin dose (units/kg/day)	1.01 ± 0.54	0.97 ± 0.55	0.98 ± 0.48	1 ± 0.48	0.96 ± 0.47	1.18 ± 0.49	1.19 ± 0.78	1.19 ± 0.49	1.16 ± 0.6
Cumulative number of deaths	3	6	8	9	10	11	13	14	15
Cumulative number of pump arrests	1	12	29	22	22	25	25	27	27
Cumulative number of patients lost to follow-up	0	1	2	3	3	3	5	6	6

Data are mean ± SD unless otherwise indicated.

Morera J et al, *Diabetes Care* 2016;39:e74-5

Infusion set failure

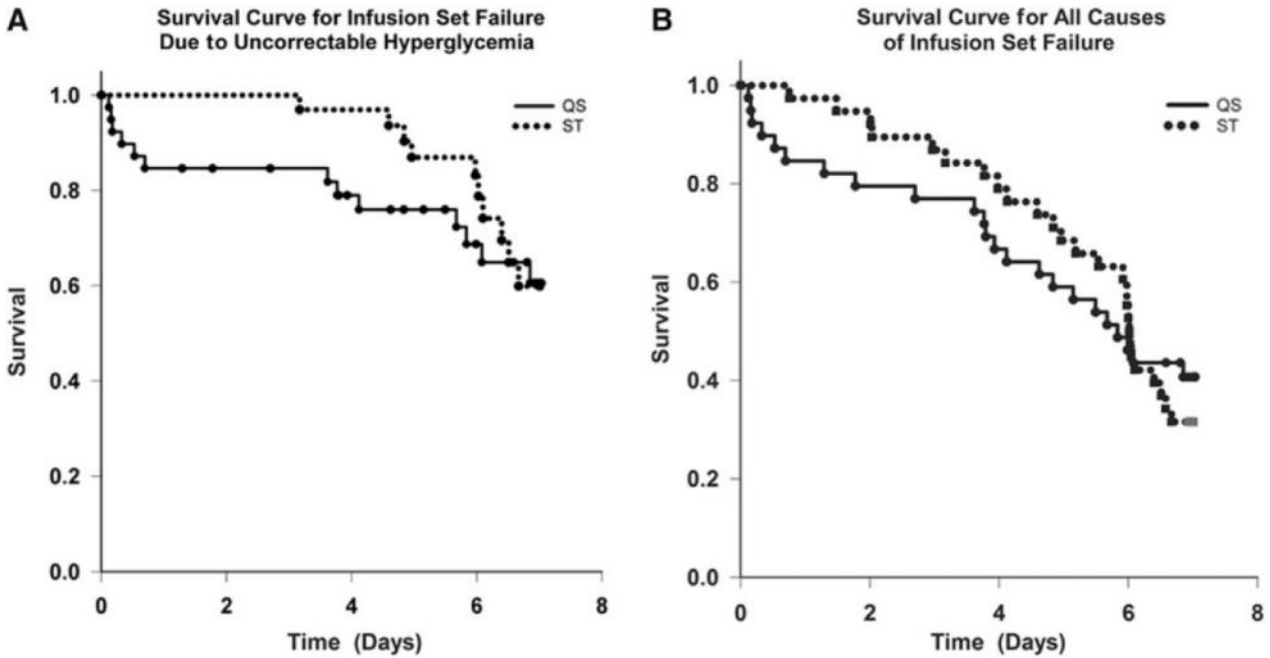


FIG. 1. Survival curves for infusion sets: **(A)** infusion set failure due to uncorrectable hyperglycemia (when the end point was hyperglycemia [>250 mg/dL] and the meter blood glucose level did not decrease by at least 50 mg/dL an hour after a correction bolus and/or blood ketone levels were greater than 0.6 mmol/L) and **(B)** for all causes of infusion set failure (uncorrectable hyperglycemia with or without ketonemia, pain, infusion set fell out [loss of adhesion], pulled out accidentally, erythema and induration, and infection). The solid line is the Teflon catheter (Quick-Set [QS]), and the dotted line is the steel needle catheter (Sure-T [ST]).

Patel P et al. *Diab Ther Tech* 2014;16:15-9

Infusion set: 2d vs 4d wear

Table 1. Patient Characteristics and Key Study Results.

Parameter	Baseline	4-day use	2-day use
HbA1c (%)	7.8 ± 1.4	7.6 ± 1.1	7.4 ± 1.2
Basal insulin dose (U)		20.2 ± 8.3	20.2 ± 8.2
Total daily insulin dose (U)		47.8 ± 19.9	45.5 ± 16.5
Hyperglycemic events (>250 mg/dL)		358	257*
Hypoglycemic events (<70 mg/dL)		450	458
Adverse events (AEs)			
Infusion set related AEs		517	305*
Treatment related AEs		467	463
Other AEs		550	324*
Injection site reactions (patients)		59	33*
Injection site reactions Health Care Professionals (HCP)		27	11*

Results are provided as mean ± SD.
*$P < .05$ vs 4-day use.

Pfutzner A et al *J Diabetes Sci Technol* 2015;9:1292-8

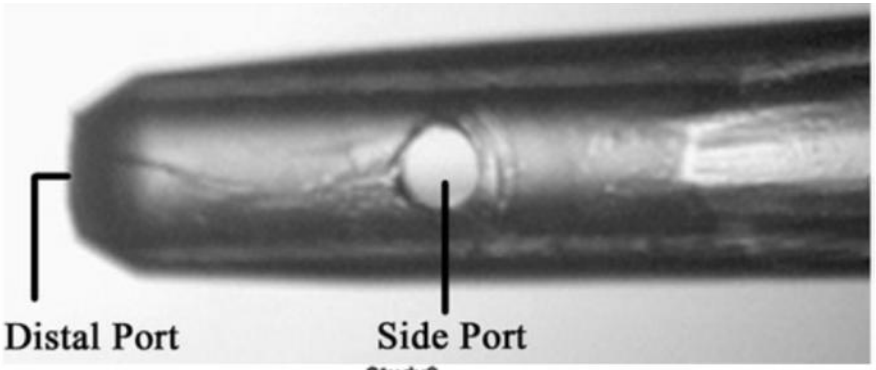
Infusion set guidelines

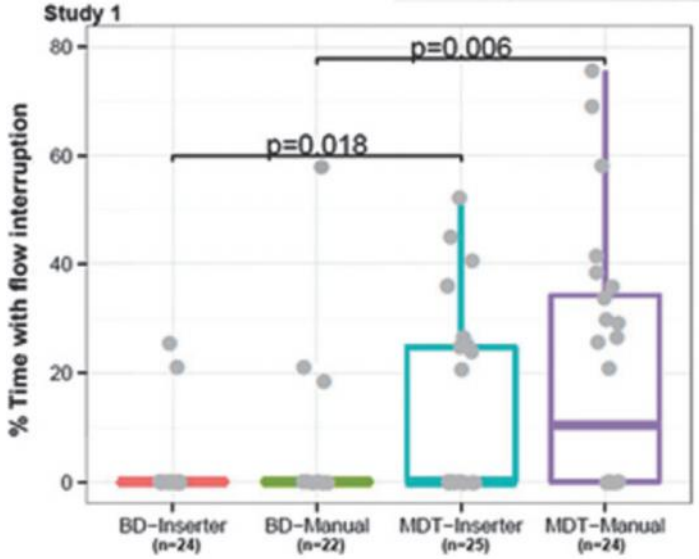
Patient Factor	Infusion Set Factor
Age	90° insertion angle easier for children learning to insert their own IISs Steel needle sets easier to teach and simpler to insert, with rare dislodgment or kinking Shorter IIS tubing length generally better for children and most adults
Pregnancy	Steel reduces risk of bent/obstructed cannula 30°-45° angle of insertion preferred when abdominal tissue becomes stretched
Dexterity and visual issues	90° angle easier in cases of poor dexterity and/or hard-to-reach sites Use of an auto-inserter may be easier Audible "click" of sideway-pull disconnection/reconnection mechanism is reassuring to visually impaired; twist-and-pull sometimes easier to manipulate
Lean/muscular	30°-45° angle reduces risk of dislodgment for lean patients
Insulin dose	Longer-length cannulae better for larger boluses (≥25 units) and higher basal rates (≥2.5 U/h)
Susceptibility to occlusions	Steel IISs eliminate kinking risk IIS with side-port catheters may reduce risk of subalarm (silent) occlusion due to in-line rises in pressure from partial or complete blockage
Needle phobia	Simplicity of 90° insertion angle may be preferred Use of a preloaded insertion device, rather than an IIS that needs to be manually placed in the insertion device by the patient, may be less stressful for some
Allergies and infection	Reactions to Teflon or nickel in steel needle may dictate choice 30°-45° angle with viewing window allows monitoring for redness around cannula insertion site
Lipohypertrophy, scarring, and/or collagen pathologies due to duration of diabetes	Rotation of the site is crucial; some patients may need to return to injections.
Physical activity	History of cannula kinking may favor steel 30°-45° angle reduces risk of dislodgment

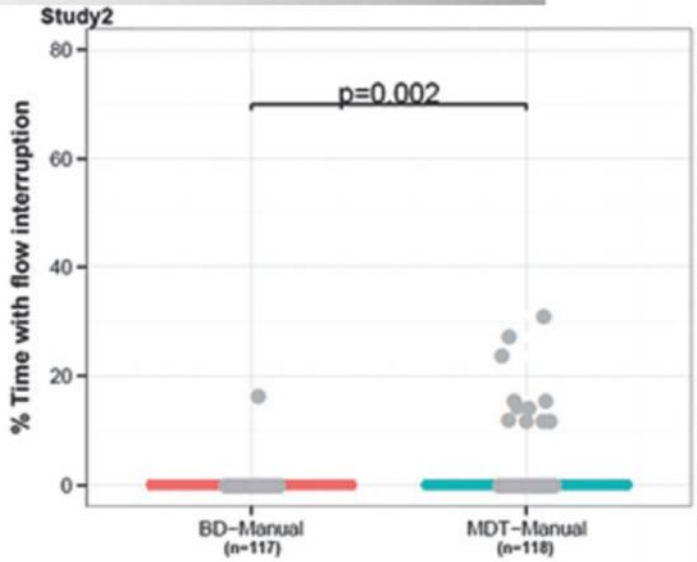
Abbreviation: IIS, insulin infusion set.

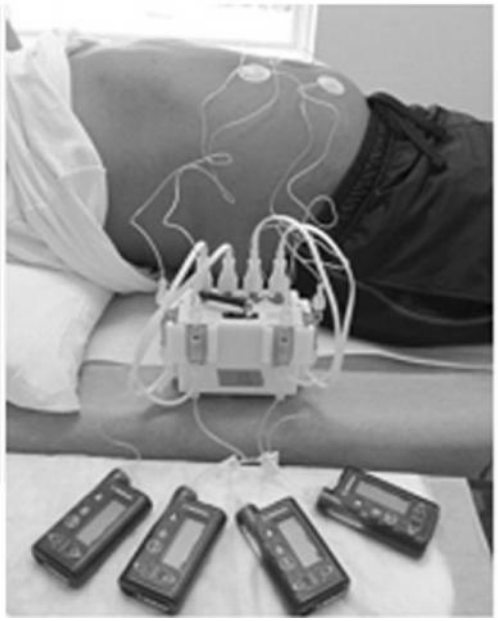
Evert A et al. *Diabetes Educator* 2016;42:470-84

BD Flow Smart



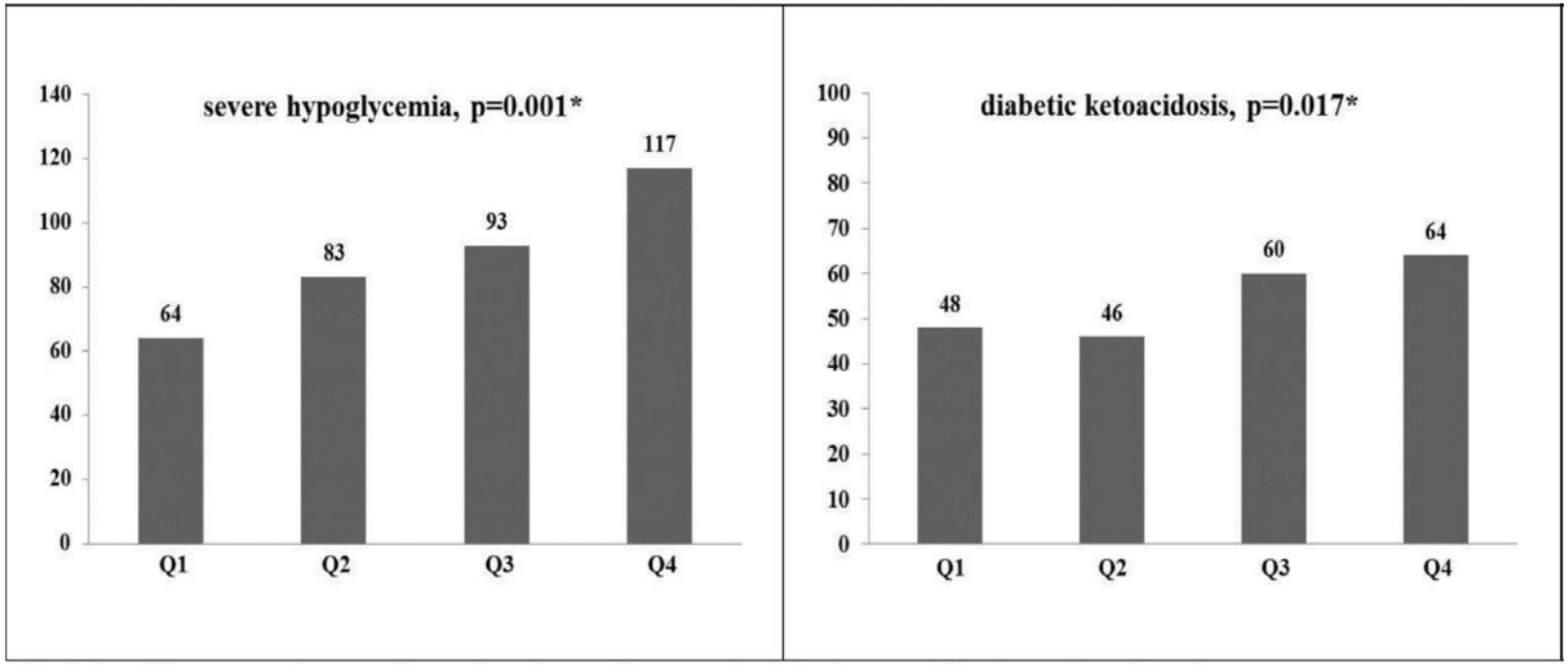






Gibney M et al. *Diab Ther Tech* 2016;18:136-43

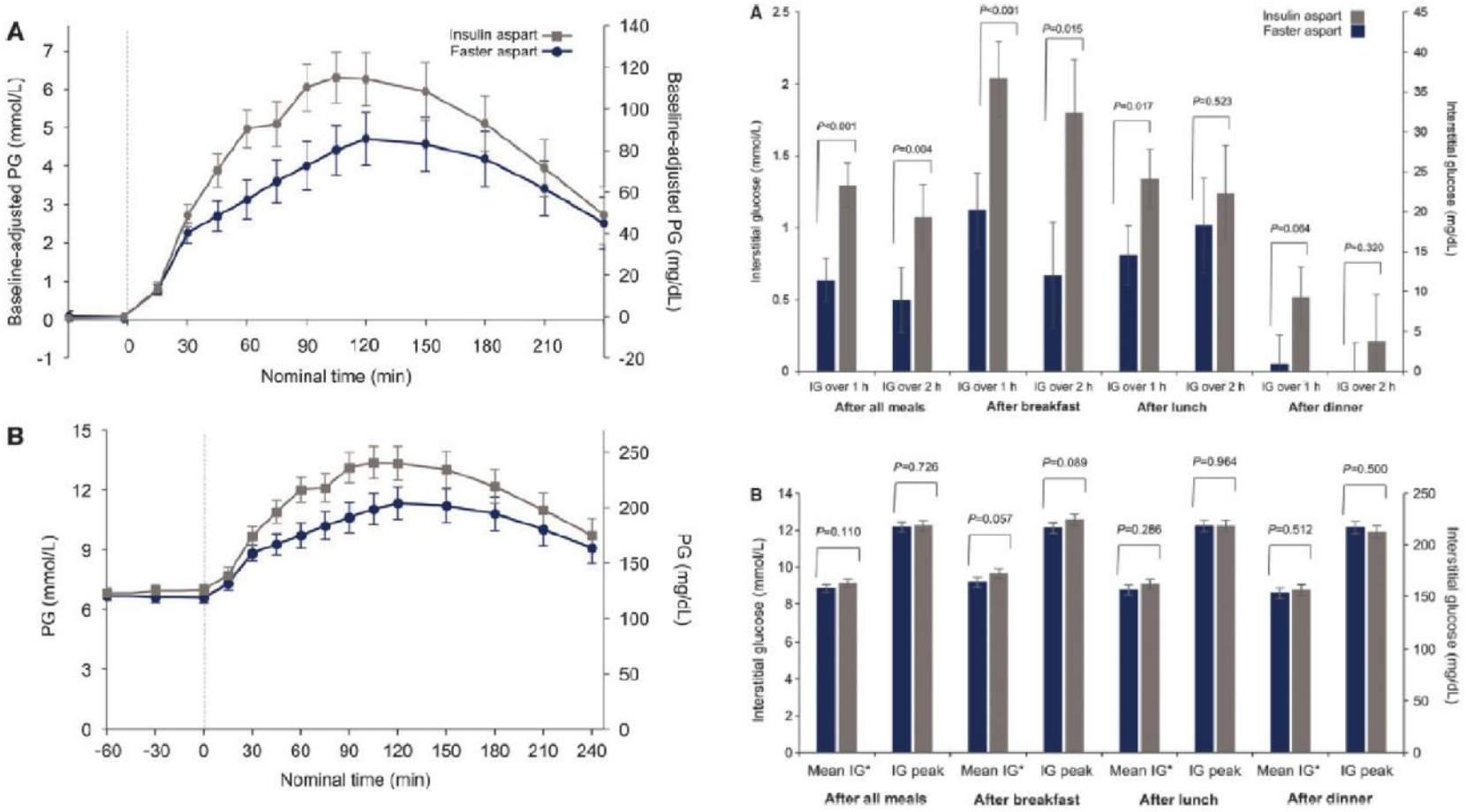
Basal rate variability and complications



Each bar illustrates the number of patients diagnosed with the specific acute complication.
*P-values derived from logistic regression model adjusted for age, duration of disease, sex, and basal rate per kilogram bodyweight.
Severe hypoglycaemia: Quartile 1,2,3=1386, quartile 4=1387 patients in total.
Diabetic ketoacidosis: Quartile 1,2,3=1386, quartile 4=1387 patients in total.
Abbreviations: Q= quartile

Lamier M et al. *PLOS One* 2016;11:e0150604

FiAsp and CSII

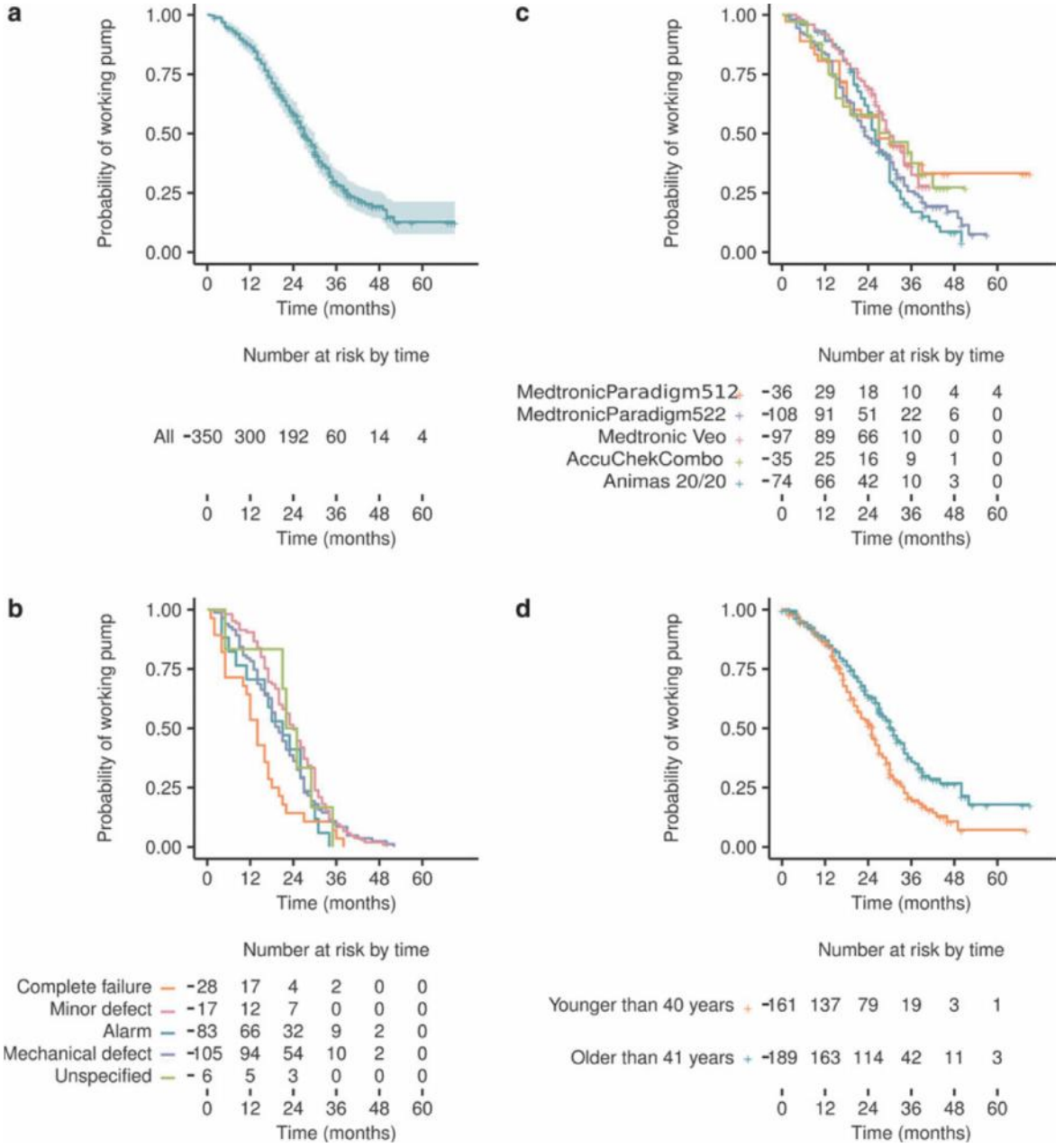


Bode B et al. *Diab Ther Tech* 2017;19:25-33

Pump failure rates

- New Zealand: 4 centres[1]
  - AE rate 3.42/100 pt-yr; 9.8% hospitalized
- French single centre: 350 pumps 2008-13[2]
  - 33 malfunctions/100 pt-yr: 19% severe failure
- Italy: 40 paediatric centres – 1547 users[3]
- Pump replacement (per 100 pt-yr):
  - NZ 16.1; Italy 16.5 – mean lifetime 2.92±2.07 yr
  - 28.5% accidental pump damage – crack; water

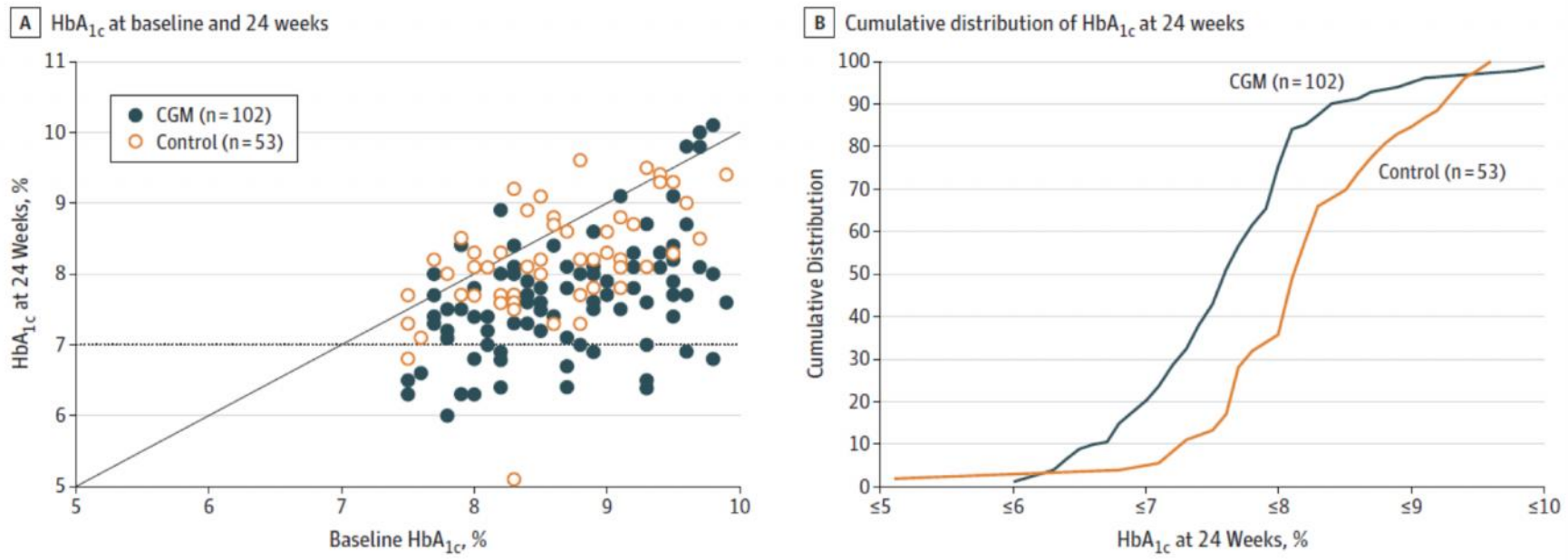
1. Ross et al. *Acta Diabet* 2016;53:991-8
2. Guenego et al. *Diab Tech Ther* 2016;18:820-4
3. Rabbone et al. *Diab Med* 2017;34:621-4



Guenego et al.
Diab Tech Ther 2016;18:820-4

DIAMOND: MDI ± CGM RCT

Figure 2. Hemoglobin A_{1c} Values at Baseline and 24 Weeks, by Group

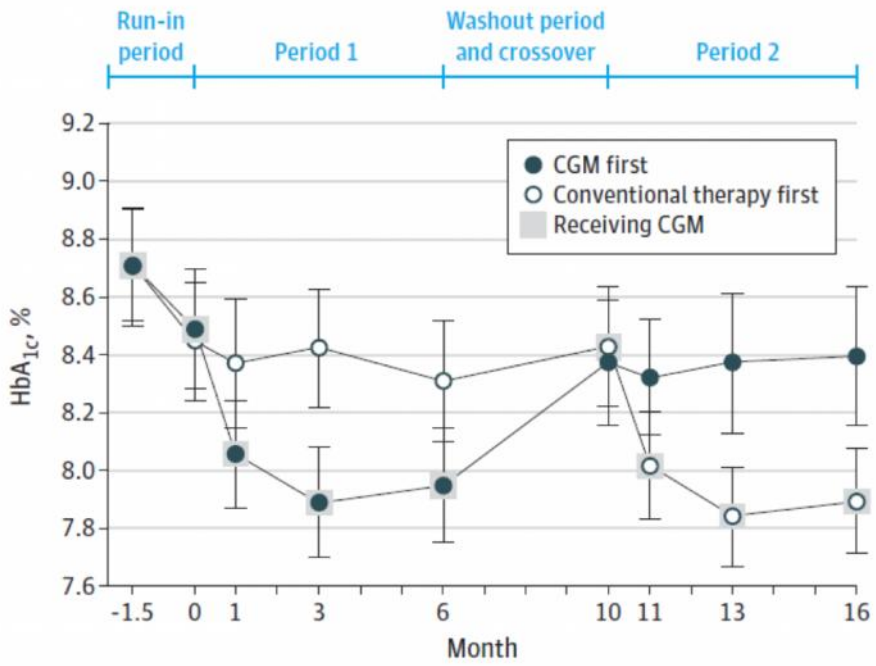


A, Scatterplot of 24-week hemoglobin A_{1c} (HbA_{1c}) levels by baseline HbA_{1c} level. The horizontal line at 7.0% represents the American Diabetes Association HbA_{1c} goal for adults with type 1 diabetes. Points below the diagonal line represent cases in which the 24-week HbA_{1c} level was lower than the baseline HbA_{1c} level, points above the diagonal line represent cases in which the 24-week HbA_{1c} level was higher than the baseline HbA_{1c} level, and points on the diagonal line represent cases in which the 24-week and baseline HbA_{1c} values were the same. B, Cumulative distribution of 24-week HbA_{1c} values. For any given 24-week HbA_{1c} level, the percentage of cases in each treatment group with an HbA_{1c} value at that level or lower can be determined from the figure. To convert HbA_{1c} to the SI units of mmol/mol, multiply the HbA_{1c} percentage value × 10.93 and subtract 23.5 from the product.

Beck RW et al, *JAMA* 2017;317:371-8

GOLD: MDI ± CGM – crossover RCT

Figure 2. HbA_{1c} Values at Inclusion, Randomization, and During the 2 Different Periods of Treatment



No. of patients									
CGM first	69	69	69	69	69	66	67	68	69
Conventional therapy first	73	72	71	73	73	73	70	73	73

Hemoglobin A1c (HbA_{1c}) was measured according to the National Glycohemoglobin Standardization Program (NGSP). Data markers and error bars indicate mean (95% CIs). Data were plotted using the last-observation-carried-forward approach.

Lind et al, *JAMA* 2017;317:371-8

REPLACE-BG: CGM ± BG

CGM results	CGM-only group: Baseline (n = 149)	CGM-only group: 26-week study period (n = 148)*	CGM+BGM group: Baseline (n = 77)	CGM+BGM group: 26-week study period (n = 76)*	P value†
Hours of CGM data	640 (620–650)	4,007 (3,709–4,166)	641 (619–651)	4,021 (3,725–4,136)	
Range	306–663	467–4,399	270–684	811–4,535	
% Time in range (70–180 mg/dL)	63 ± 13	63 ± 13	65 ± 13	65 ± 11	0.81
Mean glucose (mg/dL)	162 ± 22	162 ± 23	158 ± 22	158 ± 20	>0.99
Coefficient of variation (%)	36 (33–41)	37 (34–41)	37 (33–40)	37 (34–40)	0.58
Hypoglycemia‡					
% Time <70 mg/dL	2.9 (1.5–4.5)	3.0 (1.6–5.1)	3.6 (1.9–4.8)	3.7 (1.9–4.9)	0.95
% Time <60 mg/dL	1.1 (0.6–1.9)	1.3 (0.5–2.4)	1.4 (0.6–2.3)	1.6 (0.6–2.2)	0.57
% Time <50 mg/dL	0.3 (0.1–0.6)	0.4 (0.2–0.8)	0.4 (0.2–0.7)	0.5 (0.2–0.8)	0.75
Area above curve 70 mg/dL	0.3 (0.2–0.5)	0.3 (0.1–0.6)	0.4 (0.2–0.6)	0.4 (0.2–0.5)	0.76
% Days with ≥20 consecutive min glucose values <60 mg/dL	25 (15–43)	28 (13–42)	33 (15–43)	32 (16–46)	0.68
Hyperglycemia‡					
% Time >180 mg/dL	33 (25–43)	35 (25–41)	31 (22–40)	31 (24–38)	0.88
% Time >250 mg/dL	8 (4–15)	9 (5–13)	7 (3–11)	7 (4–11)	0.65
% Time >300 mg/dL	2 (1–5)	2 (1–4)	2 (1–4)	2 (1–3)	0.72
Area under curve 180 mg/dL	17 (10–25)	17 (10–23)	14 (8–22)	15 (9–21)	0.90
% Days with ≥20 consecutive min of glucose values >300 mg/dL	25 (12–48)	27 (14–40)	20 (8–36)	20 (10–37)	0.72
HbA_{1c} results	Baseline (n = 149)	Week 26 visit (n = 142)	Baseline (n = 77)	Week 26 visit (n = 75)	P value†
HbA_{1c}					
%	7.1 ± 0.7	7.1 ± 0.7	7.0 ± 0.7	7.0 ± 0.6	
mmol/mol	54 ± 7.7	54 ± 7.7	53 ± 7.7	53 ± 6.6	
Change in HbA_{1c} from baseline					0.41
%		0.0 ± 0.5		0.0 ± 0.5	
mmol/mol		0.0 ± 5.5		0.0 ± 5.5	
No worsening of HbA_{1c} by >0.3% (3.3 mmol/mol) and no severe hypoglycemic event		115 (81)		54 (72)	0.15

Data are median (interquartile range), mean ± SD, or n (%) unless otherwise indicated. *One participant in the CGM-only group and one in the CGM +BGM group never came in for a follow-up visit and therefore had no CGM data; †two-sided P value for the CGM metrics and change in HbA_{1c} are from ANCOVA models adjusted for the corresponding baseline value and site as a random effect. Because of the skewed distributions for the CGM coefficient of variation, as well as the CGM hypoglycemia and hyperglycemia metrics, these models were based on van der Waerden score rankings. The P value for the HbA_{1c}/severe hypoglycemia combined outcome is from a logistic regression model adjusted for baseline HbA_{1c} and site as a random effect. Results were similar for the % time in range when also adjusting for education; ‡1% time equals 14.4 min/day.

Aleppo G et al, *Diabetes Care* 2017;40:538-45

Freestyle Libre – IMPACT?

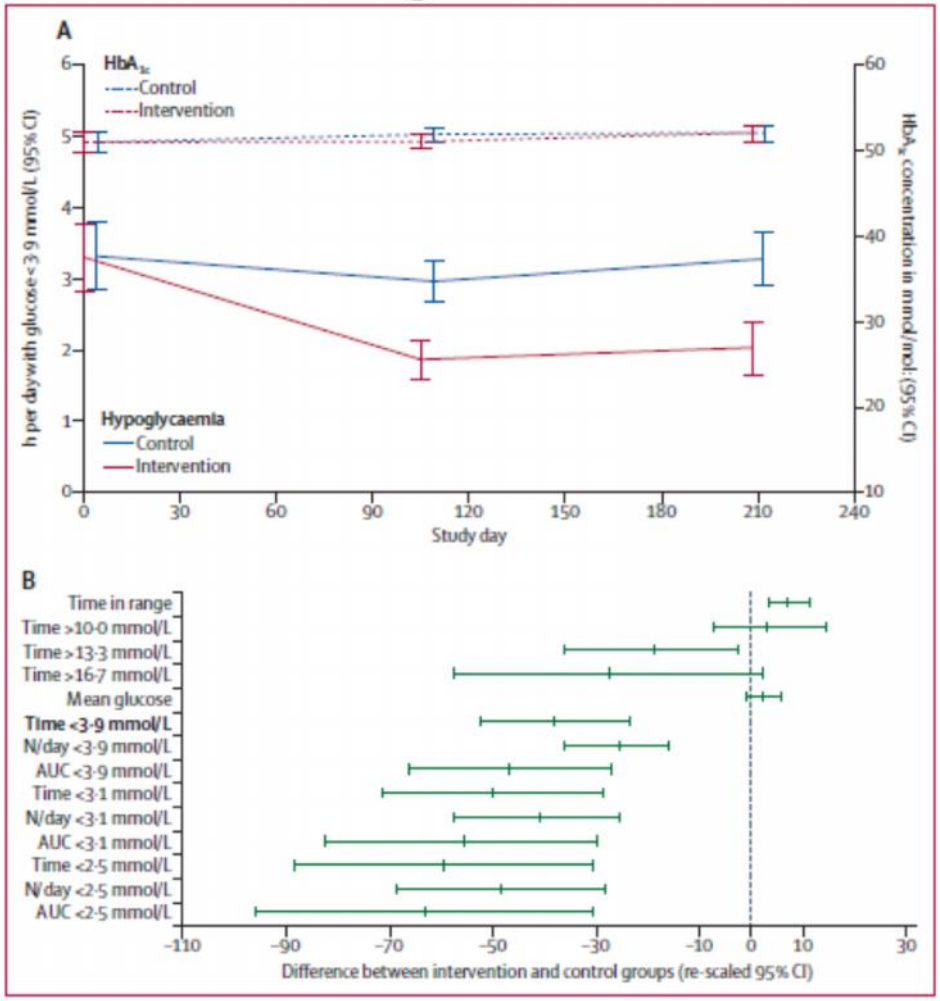


Figure 2: Difference in groups for changes in time with hypoglycaemia and HbA_{1c} (A) and with glucose higher or lower than glycaemic thresholds (B)

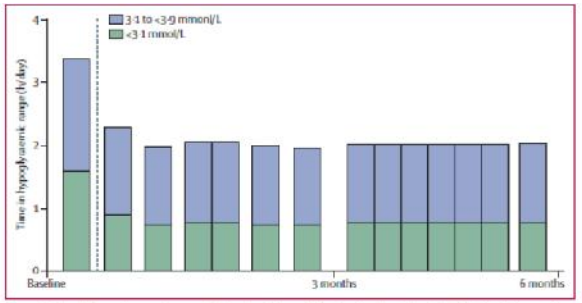


Figure 3: Time in hypoglycaemic range during baseline and treatment phase (days 1–208) in the intervention group in the per-protocol set
Grouped bars indicate analysis performed over 2 week periods and then averaged. Dashed line marks the start of the intervention.

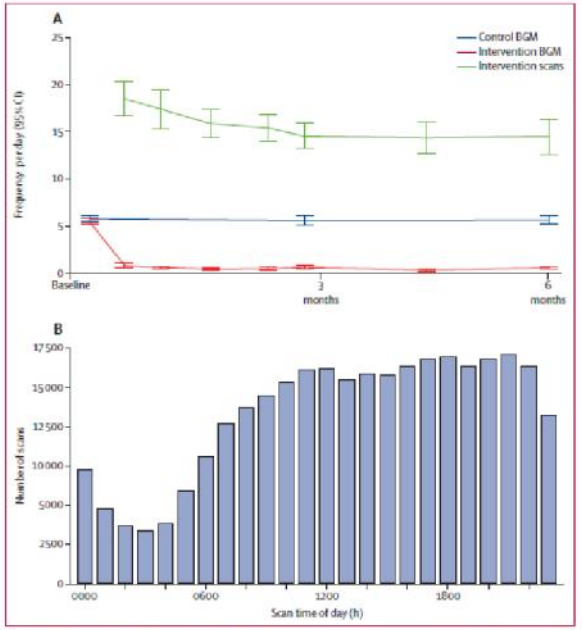


Figure 4: Glucose monitoring frequency (A) and total number of scans by time of day in the intervention group (B)
Number of scans performed across all intervention participants over 6 months by time of day.
BGM=blood glucose monitoring.

Bolinder J et al *Lancet* 2016;388:2254-63

Libre – real-life experience

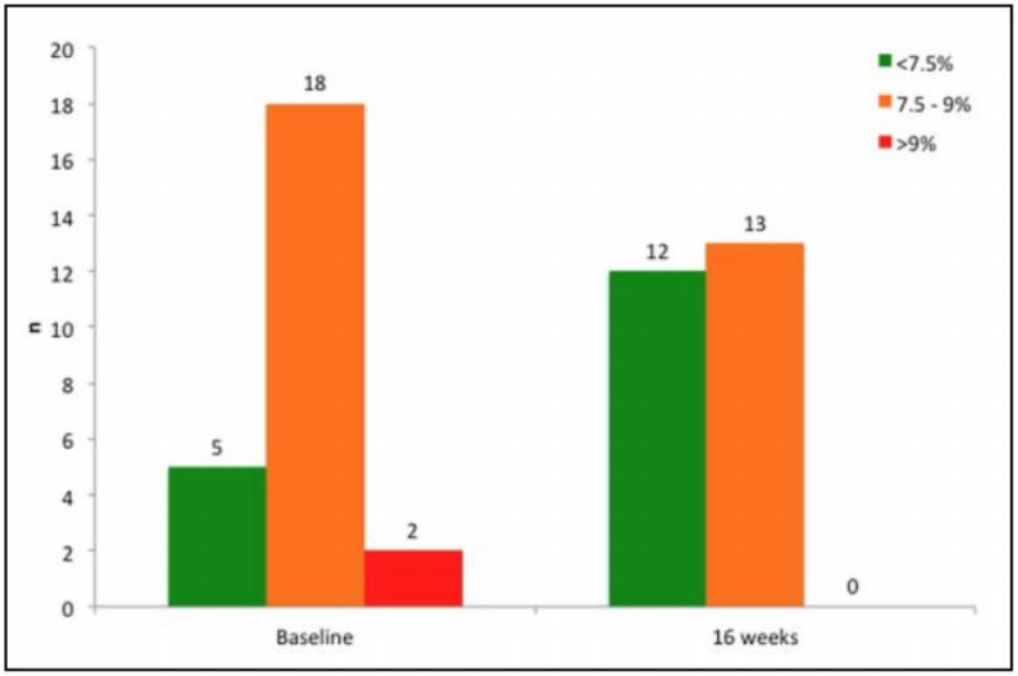


Figure 1. FGM increases the proportion of patients achieving good glycemic control. Data were analyzed using the chi-squared test. $P = .015$ comparing those below target (<7.5%) at baseline and at end of FGM use.

Dover AR et al *J Diabetes Sci Technol* 2017;11:442-3

Libre - accuracy

- Swedish study, 52 subjects, use over 14 days[1]:
  - MARD 13.2%
  - For BG < 3 mmol/l: MARD 20.3%
  - Positive experience 8.22-9.8/10
- Austrian study, 12 subjects, use CGMx3 over 12 hours[2]:
  - MARD:
    - Libre 13.2±10.9%
    - Dexcom 16.8±12.3%
    - Medtronic 21.4±17.6%

1. Olfasdottir AF et al. *Diab Ther Tech* 2017;19:164-72
2. Aberer F et al. *Diabetes Obes Metab* 2017;epub

KEEP YOUR GLUCOSE IN RANGE WITH OUR MOST ADVANCED SMARTGUARD® HCL TECHNOLOGY.

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- Quick and easy bolus from your meter.
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LIVE OUT LOUD.

Nicky just wants to be like any other teenager.

Nicky used to inject herself many times each day. It was a mental and physical struggle that interfered with what she enjoys most: getting together with her friends for hikes, dancing, and attending sleepovers. Today she enjoys each moment to its fullest, knowing that her glucose levels are automatically kept in range*,** by the MiniMed 670G system.

John. Active in the extreme.

John's passion? Extreme sports. The MiniMed 670G system not only lets John participate in the sports he loves, it also helps his performance by keeping him in range, come rain or shine.

"I forget that I have diabetes."

JOHN
Active professional
Minnesota

Live life more spontaneously.

Sports can dramatically lower glucose levels. That's why people with diabetes typically check their glucose before they start athletic activity — then check again an hour or two later to ensure that their glucose isn't dropping too low. The Auto Mode feature gives you the option to temporarily change your glucose target to help you maintain a safe range. The waterproof[†] MiniMed 670G system makes activity and adventure easier and safer.[1]

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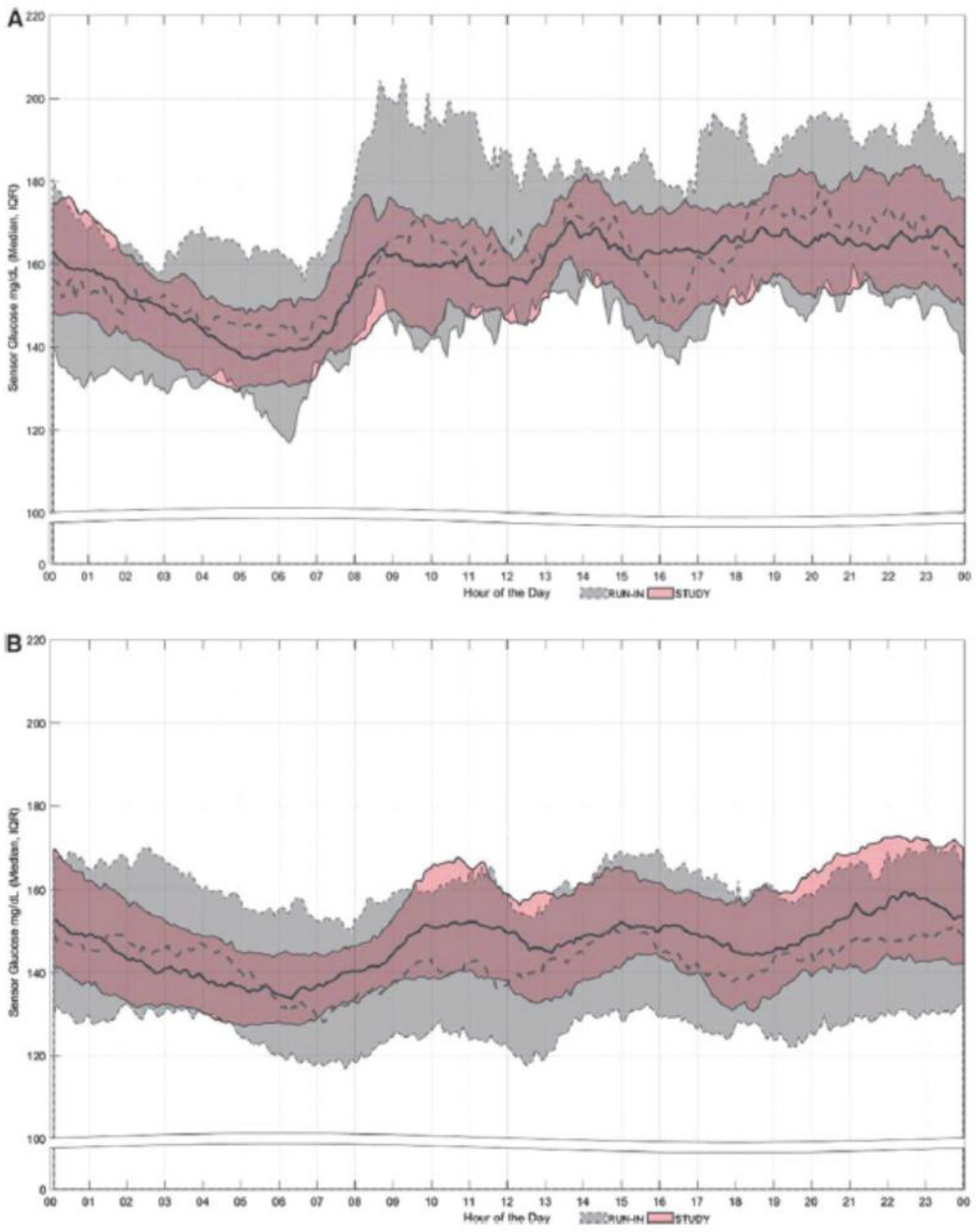
670G

- Manual mode – equivalent to 640G
- Auto mode
  - Basal rate adjustment at 5 minute intervals
  - Maintain BG at target: 6.67 mmol/l default; 8.83 mmol/l for exercise ….
  - Safe basal mode

Hybrid closed-loop

- 670G vs SAP w/o automation
- 124 subjects:
  - 94 adults, 30 adolescents
- HbA1c reduction 0.5%: from 7.4 to 6.9%
- 40% decline in time under 2.8 mmol/l
- 11% decline in time under 10 mmol/l
- HbA1c < 7.0%: 55% vs 31%
- 87.2% time in closed loop mode

Bergenstal RM et al, *JAMA* 2016;316:1407-8



Garg S et al. *Diab Ther Tech* 2017;19:155-63

Cyber Safety

DATA CENTRE SOFTWARE SECURITY TRANSFORMATION DEVOPS BUSINESS PERSONAL TECH SCIENCE EMERGENT TECH BOOTNOTES

Insulin pump hack delivers fatal dosage over the air

Sugar Blues, James Bond style

27 Oct 2011 at 06:23, Dan Goodin

In a hack fitting of a James Bond movie, a security researcher has devised an attack that hijacks nearby insulin pumps, enabling him to surreptitiously deliver fatal doses to diabetic patients who rely on them.

The attack on wireless insulin pumps made by medical devices giant Medtronic was demonstrated Tuesday at the Hacker Halted conference in Miami. It was delivered by McAfee's Barnaby Jack, the same researcher who last year showed how to take control of two widely used models of automatic teller machines so he could to cause them to spit out a steady stream of dollar bills.

Jack's latest hack works on most recent Medtronic insulin pumps, because they contain tiny radio transmitters that allow patients and doctors to adjust their functions. It builds on research presented earlier this year that allowed the wireless commandeering of the devices when an attacker was within a few feet of the patient, and knew the serial number of his pump. Software and a special antenna designed by Jack allows him to locate and seize control of any device within 300 feet, even when he doesn't know the serial number.

"With this device I created and the software I created, I could actually instruct the pump to perform all manner of commands," Jack told *The Register*. "I could make it dispense its entire reservoir of insulin, which is about 300 units. I just scan for any devices in the vicinity

Most read

Sackner-Bernstein J et al *J Diabetes Sci Technol* 2017;11:198-202

Thought for the year!

- The hybrid closed loop is within reach

BUT improvements are needed:

- Pump reliability
- Infusion set technology
- CGM accuracy
- Cyber security?!