Insulin Pump Therapy in children

Prof. Abdulmoein Al-Agha, FRCPCH(UK)

aagha@kau.edu.sa

Highlights

- Evolution of insulin pump
- Pumps mimics Pancreas
- Goals of diabetes care
- What lowers HbA1c
- Criteria for selection for CSII
- Advantage/ disadvantage of CSII
- Smart pumps
- Future of pumps

The Miracle of Insulin

Patient J.L., December 15, 1922

February 15, 1923

With Out Insulin

With Treatment of Insulin

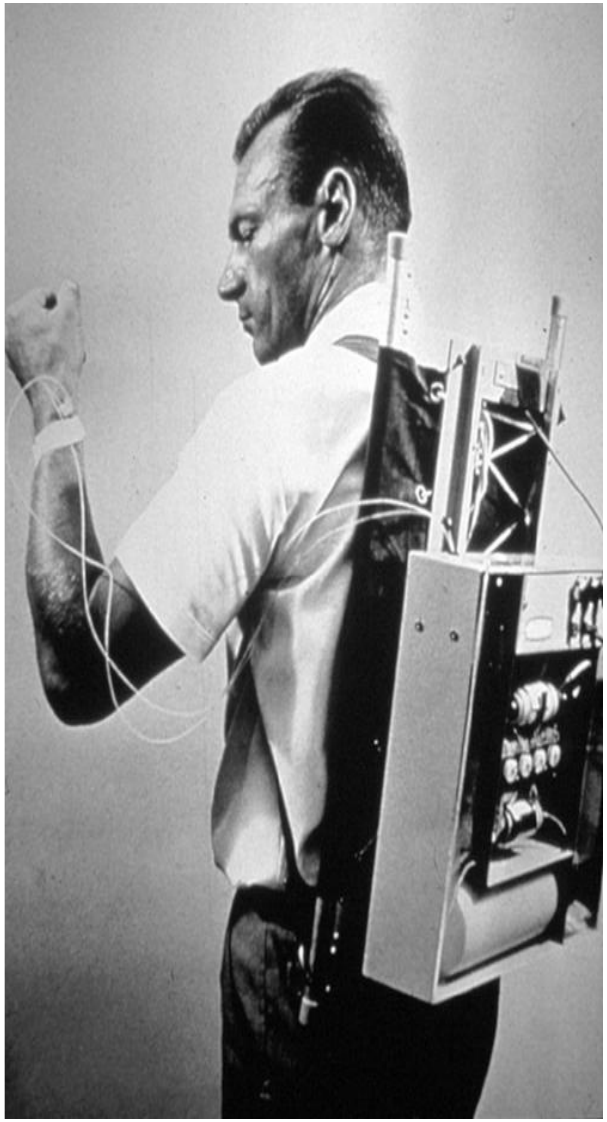
Insulin Delivery Devices

- Syringe
- Pump
- Pen Device

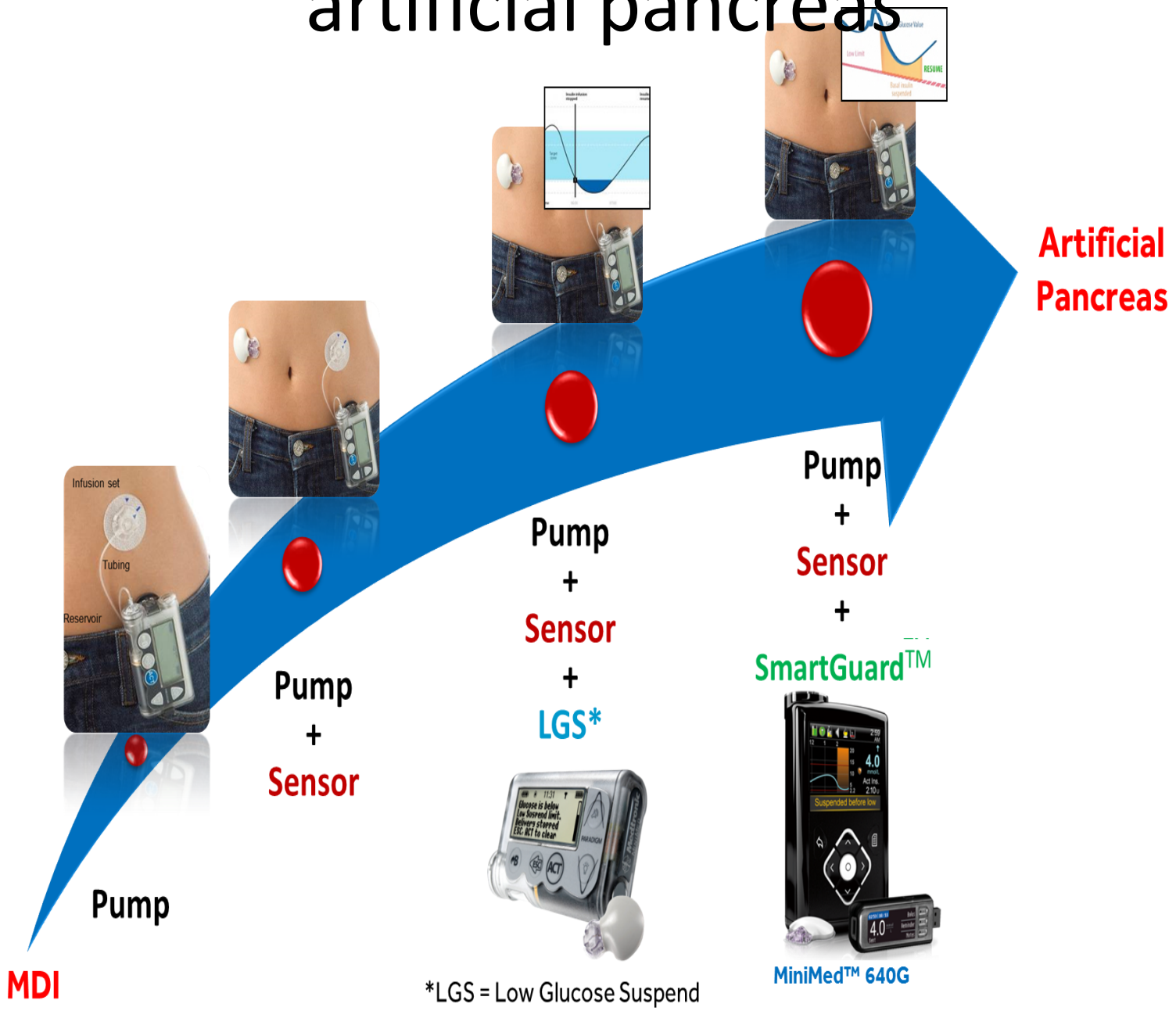
EVOLUTION OF INSULIN PUMP THERAPY

- The idea of continuous insulin delivery first emerged in the early 1960s when Dr Arnold Kadish from Los Angeles fashioned a device that would permit such insulin delivery
- This device was the size of an army backpack making it impractical for everyday use
- First pump employed continuous intravenous insulin delivery, and then by the more practical means of continuous subcutaneous insulin infusion (CSII)

Insulin Pump Therapy: Past



Evolution in diabetes technology towards artificial pancreas

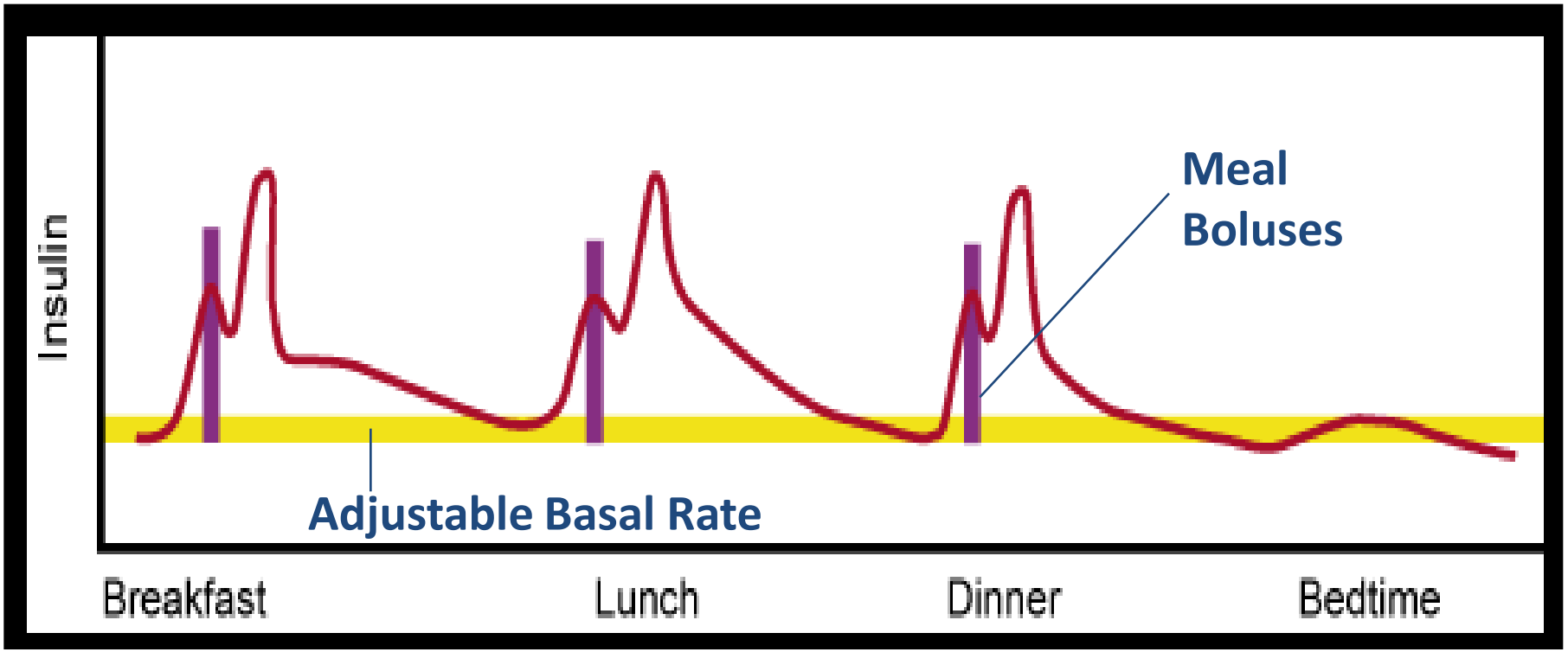


Insulin Pump Therapy: Present

Coming Soon


2:59
AM
12 1 2
20
15
10
5
2.2
4.0
mmol/L
Act Ins.
2.10 U
Suspended before low
0253 10/11
4.0
mmol
L
Sent
Bolus
Reminder
Notes

The Pump Mimics the Pancreas



Benefits of Insulin Pump Therapy

- Improved glycemia control
- Less frequent / severe hypoglycemia
- Enhanced quality of life
- Improved patient satisfaction
- Ease of management
- Reduced glucose toxicity, which may also result in improved β-cell function

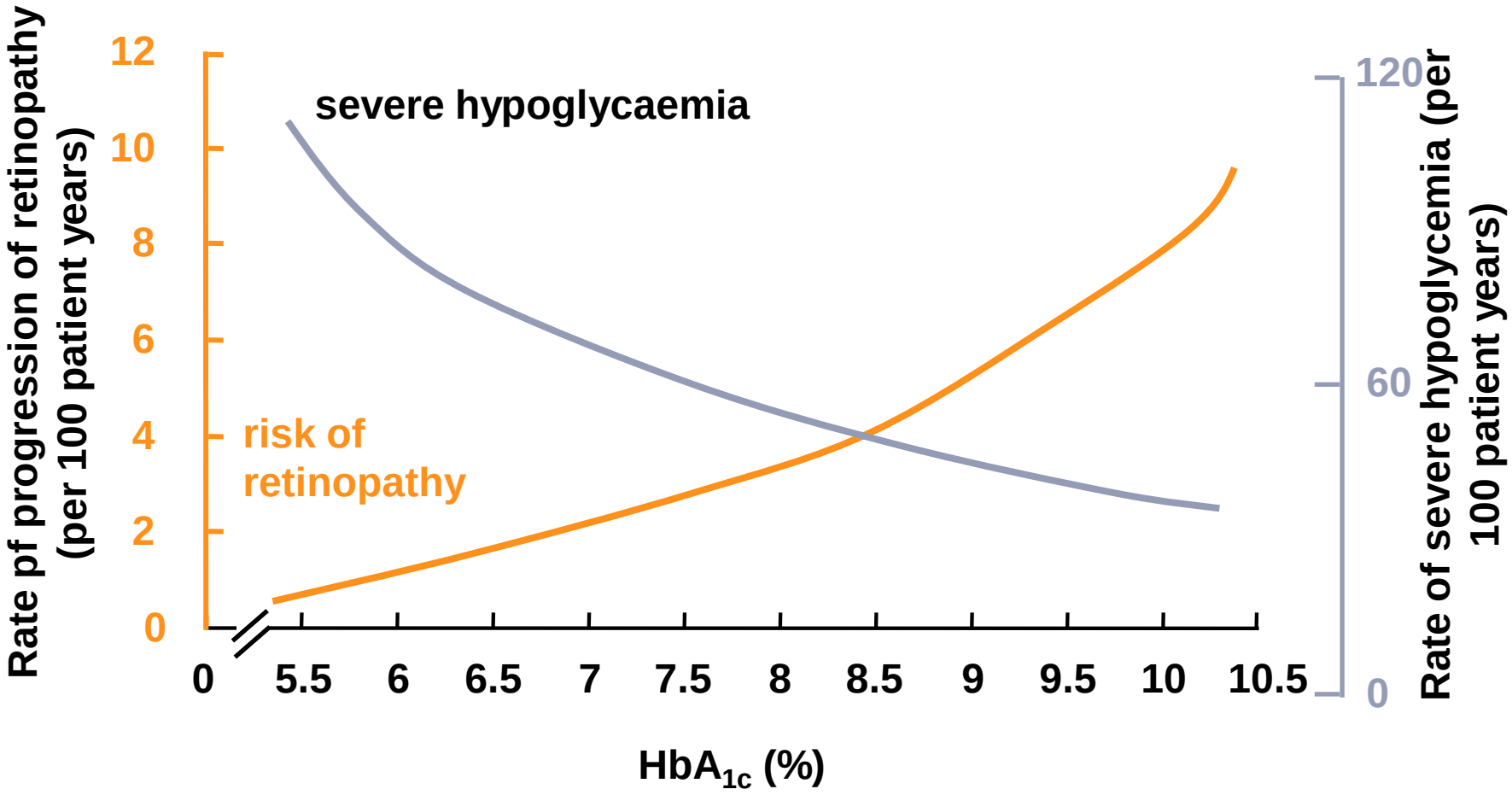
1. Wainstein J, et al. *Diabet Med*. 2005;22(8):1037-1046.
2. Labrousse-Lhermine F, et al. *Diabetes Metab*. 2007;33(4):253-260.

What Lowers The A1c

- Frequent testing *
- Frequent boluses *
- Rapid insulin *
- Accurate carb counting *
- Easy bolus calculations *
- Easy history *
- Basal can be adjusted to precise need *
- Bolus based on carbohydrates and BG *
- Properly set doses

*** Where a pump helps**

DCCT: the price of improved diabetic control – hypoglycaemia



Adapted from: N Engl J Med 1993;329:977–86

Pump Therapy Team

1. Endocrinologist
2. 24 – hour technical support company representative
3. Dietician
4. Pump therapy Nurse
5. 24 –Hour hotline contact

CSII Candidate Selection

- Patient Requirements
  - Motivated, educated and reliable parents
  - Willing to monitor and record BG
  - Willing to quantify food intake “Carbohydrate counting”
  - Willing to follow-up regularly

Consensus Statement on Pump Use in Paediatric- Patient Selection

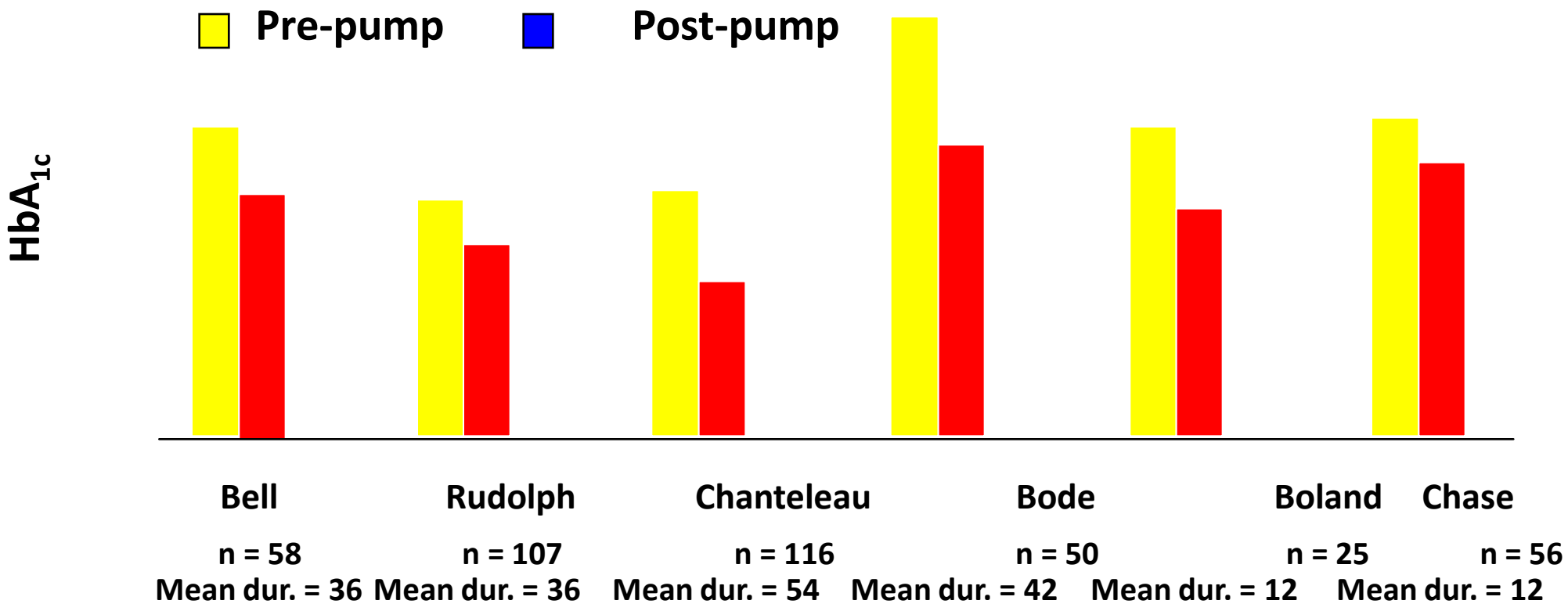
- Recurrent severe hypoglycemia
- Wide fluctuations in glucose readings regardless of A1c
- Suboptimal diabetes control
- Micro/macro vascular complications
- Good control but regimen compromises lifestyle
- Infants and neonates
- Children with needle phobia

ADVANTAGES

Normalization of Lifestyle

- Liberalization of diet — timing & amount
- Increased control with exercise
- Able to work shifts & through lunch
- Less hassle with travel — time zones
- Weight control
- Less anxiety in trying to keep on schedule

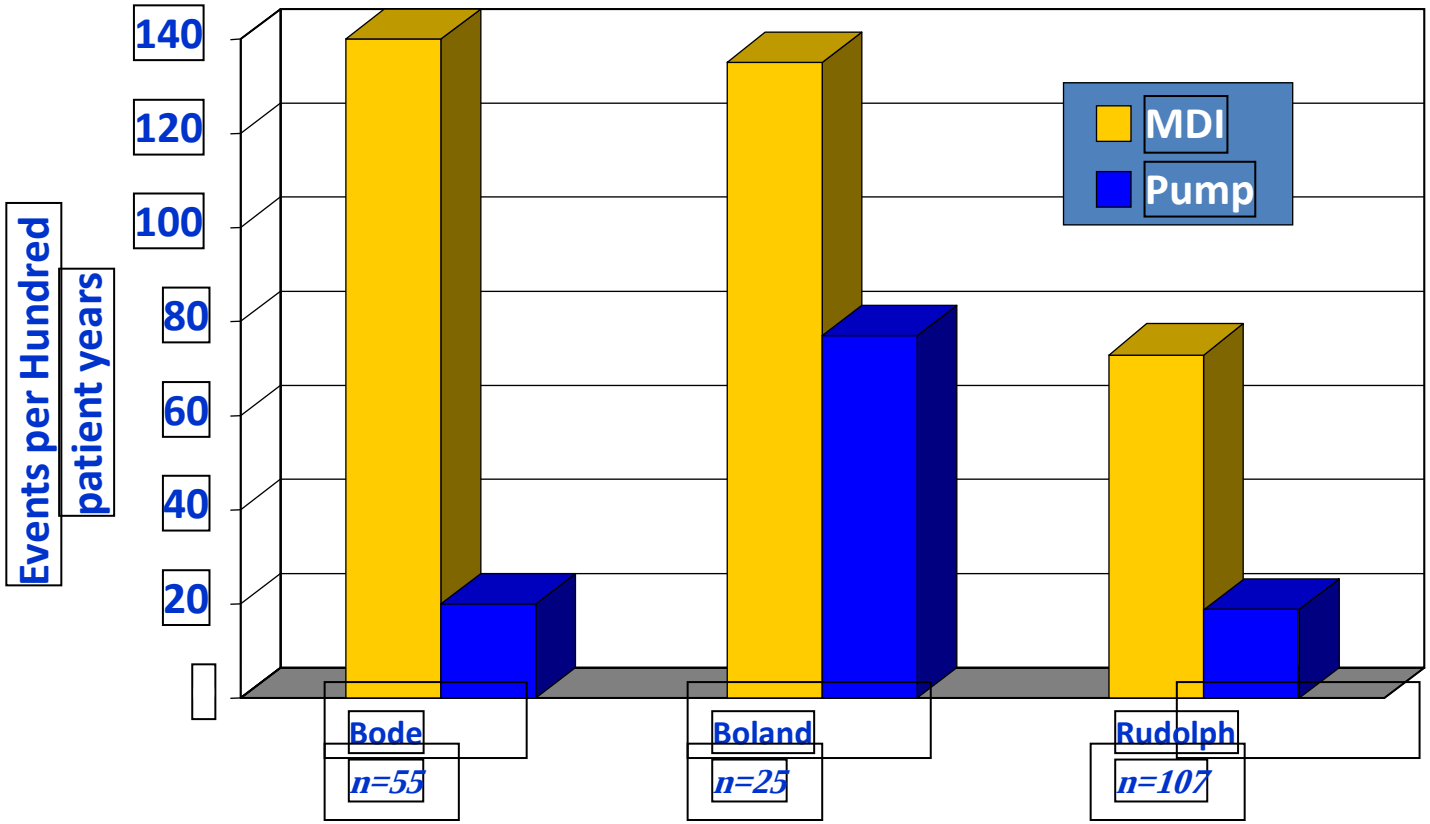
CSII Reduces HbA_{1c}



Chantelau E, et al. *Diabetologia*. 1989;32:421–426; Bode BW, et al. *Diabetes Care*. 1996;19:324–327; Boland EA, et al. *Diabetes Care*. 1999;22:1779–1784; Bell DSH, et al. *Endocrine Practice*. 2000;6:357–360; Chase HP, et al. *Pediatrics*. 2001;107:351–356.

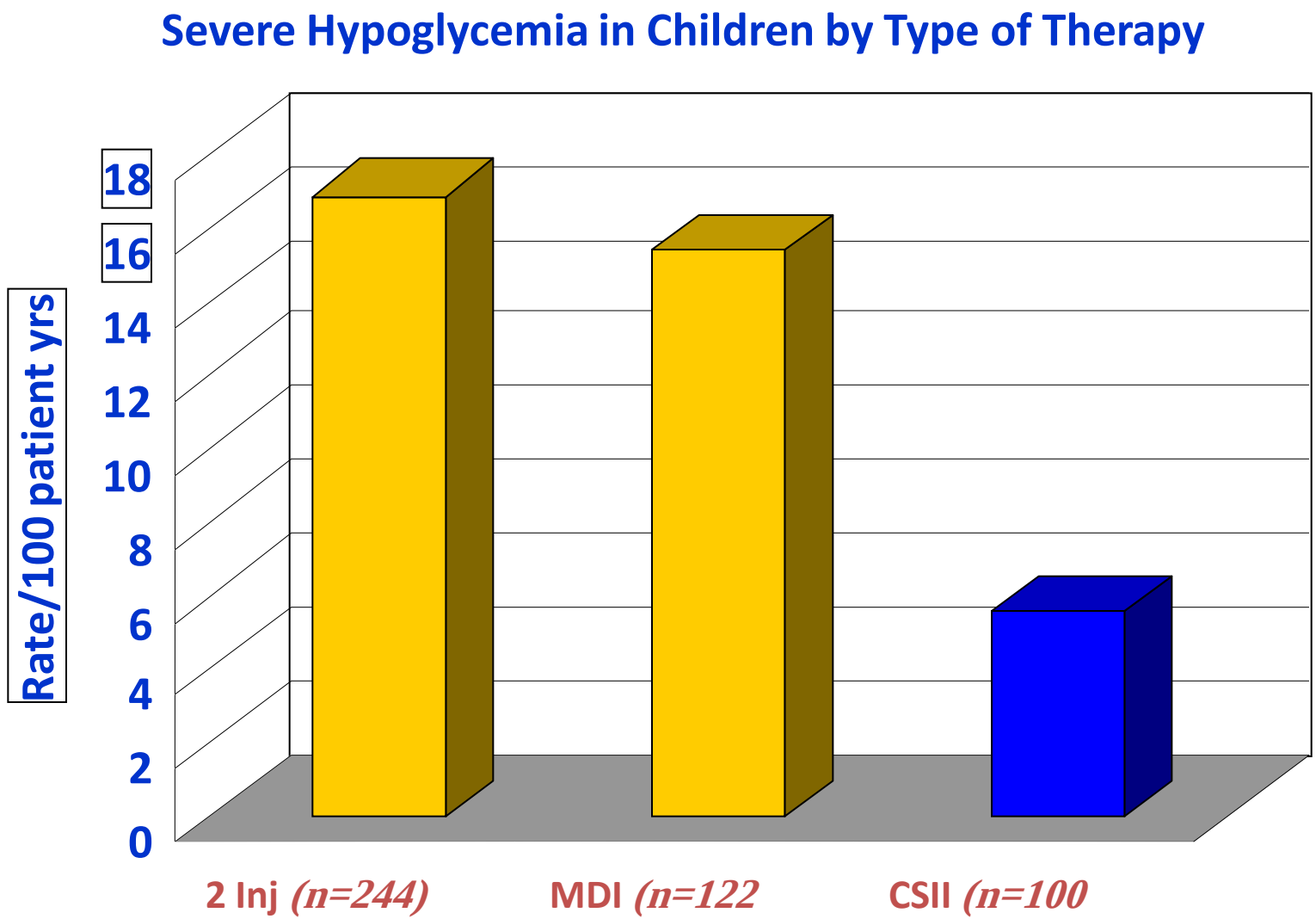
Pump Therapy Reduces Incidents of Severe Hypoglycemia

Severe Hypoglycemic Episodes MDI vs CSII



Adapted from Bode,BW et al., Diabettes Care *1996, 19:325-7. Boland, EA et al.,* Diabetes Care *1999, 22:1779 - 84. Rudolph JW, Hirsch IB. Assessment of Therapy with ContinuousSubcutaneous Insulin Infusion in an Academic Diabetes Clinic.* Endocrine Practice *2002: 8; 401 - 405*

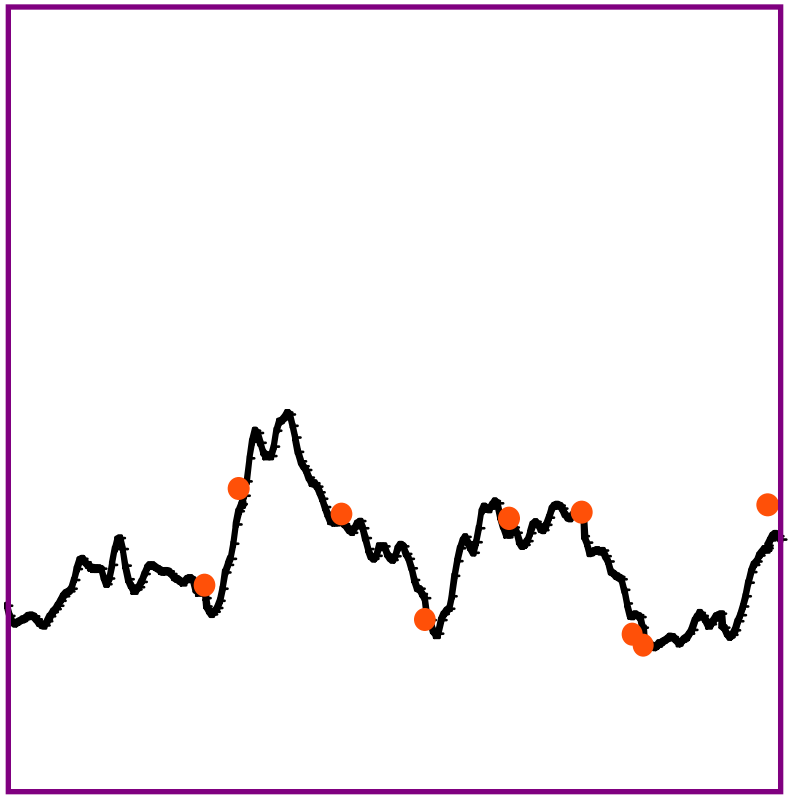
Decreased Risk of Severe Hypoglycemia



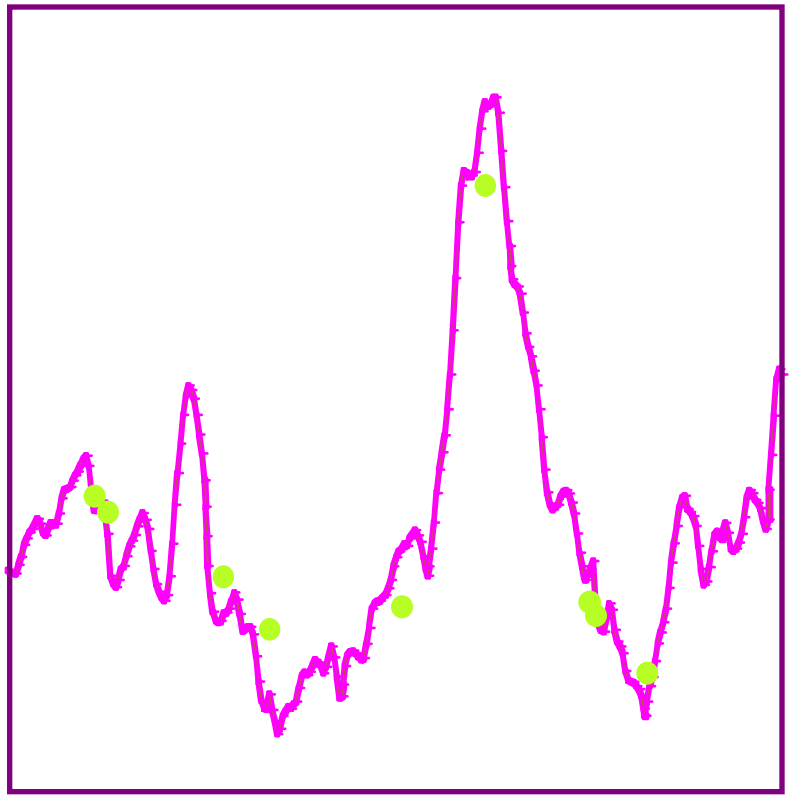
Adapted from Jones TW, Davis EA. Hypoglycemia in Children with Type 1 Diabetes: Current Issues and Controversies. Pediatric Diabetes *2003; 4: 143*

CGMS shows:
Less Variability With Pump Therapy

Insulin pump



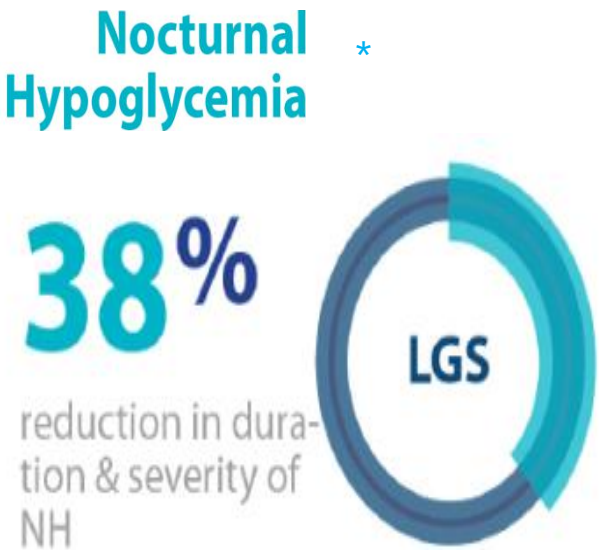
Multiple daily injections

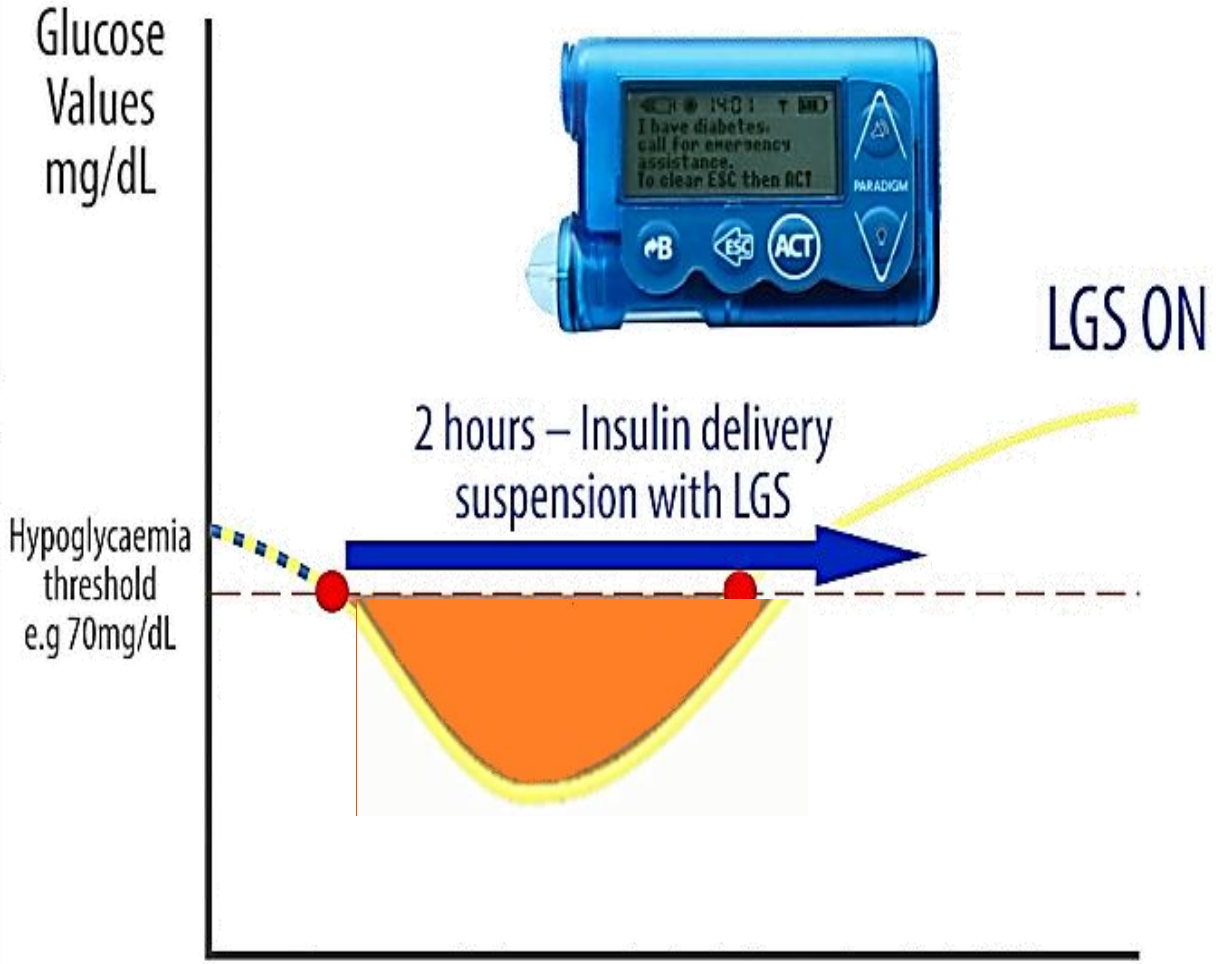


‘SMARTGUARD™ TECHNOLOGY PROVIDES ADVANCED PROTECTION AGAINST HYPOGLYCEMIA (AUTO SUSPENSION & AUTO-RESUME OF INSULIN)

‘LOW GLUCOSE SUSPEND (LGS)’ MINIMIZES SEVERE HYPOGLYCEMIA

MiniMed® Paradigm Veo™ with LGS is the ONLY automated insulin delivery system clinically proven to significantly reduce hypoglycaemia



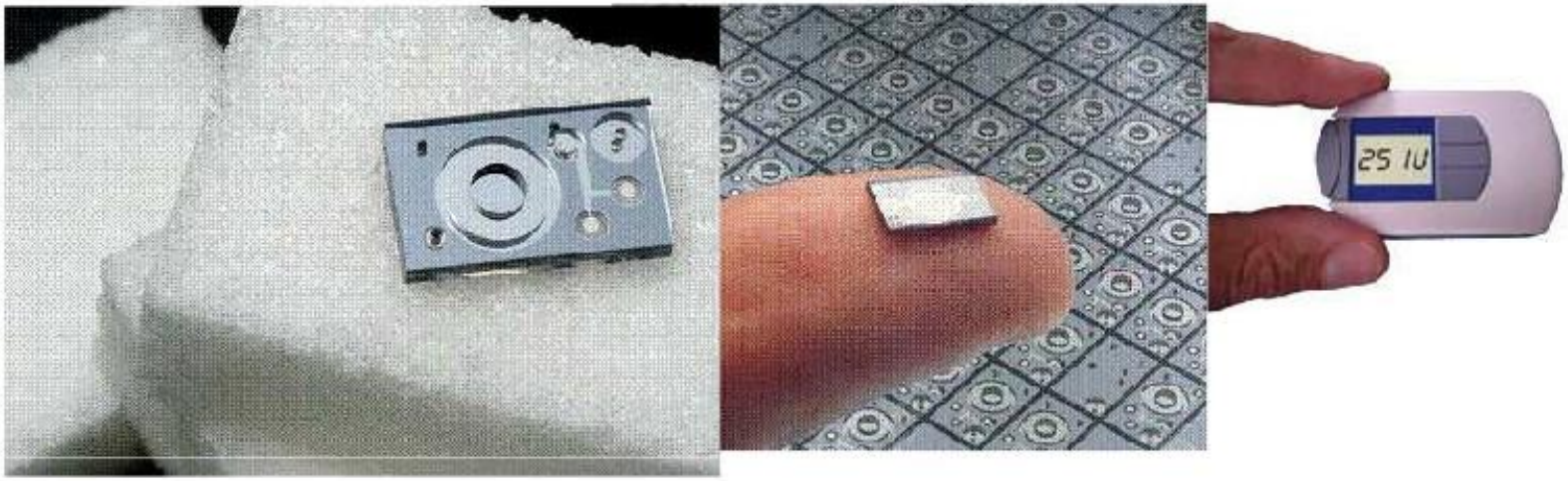


Insulin Pump Disadvantages

- Expense
- Requires SBGM more frequent at least 4-6 times a day
- Must be worn 24 hours per day
- Should not be removed for > ~60 min
- Increased risk of DKA due to technical kinking of needles or tubes or failure to deliver insulin
- Must learn to adjust insulin for food & exercise accurately

Future Development

Micro-pump



Debiotech has been developing small pumps from Micro-Electro-Mechanical Systems or MEMS technology. These devices are made from silicon (not silicone!) and easily mass-produced to keep cost low.

Silicon is harmless, but it is not clear how insulin may interact with silicon surfaces.

Insulin pump technology is to combine with a continuous blood glucose monitoring system

“2 in 1 machine”

Clinical trials: implantable insulin pumps and continuous glucose sensors

Ultrafast insulin which are absorbed more quickly than the currently available rapid acting insulin which have a peak at about 60 minutes

It theoretically coordinate with meals better, and allow faster recovery from hyperglycemia if the insulin infusion is suspended.

They are in development by Biodel Halozyme, and Novo Nordisk

Future Pump Features

Automatic TDD adjustment

- Average blood sugar and standard deviation
- % TDD used for corrections
- Basal/bolus balance

Automatic basal testing

- Overnight
- Daytime, when meal is skipped

Automatic carb factor testing

- Premeal, 2 hr postmeal peak, normal in 4-5 hrs?

Automatic correction factor testing

- High-to-normal in 4-5 hours?

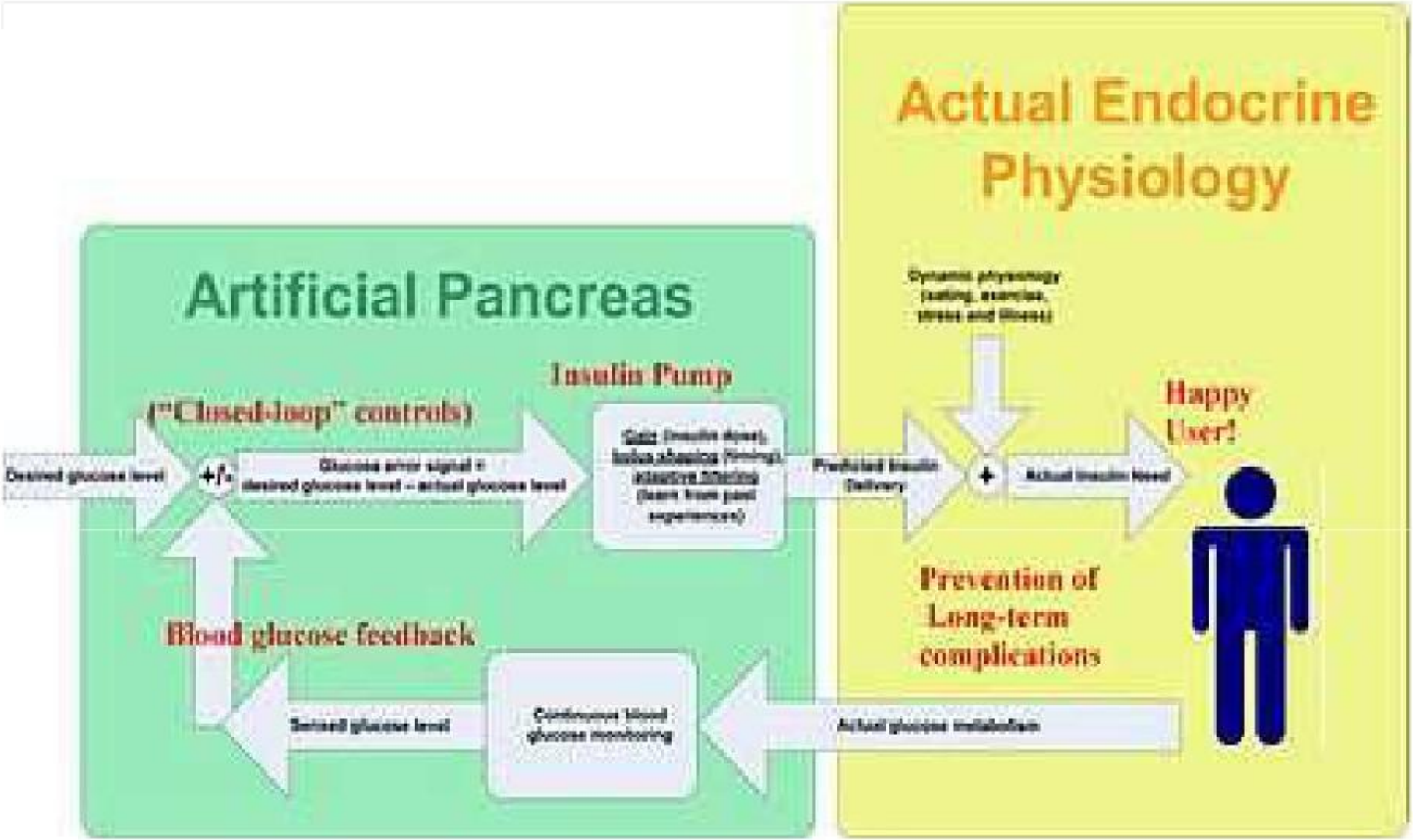
Our Dream !!

An Artificial Pancreas

“ Closed Loop System”

The artificial pancreas (AP)

- known as closed-loop control of blood glucose in diabetes, is a system combining;
  - glucose sensor
  - **smart" control algorithms**
  - insulin infusion device



Feedback of real-time blood glucose data to an insulin pump for basal & bolus control

Automated insulin pump basal control

- The first step in controlling an insulin pump based on continuous blood glucose data is to automatically control the basal rate of the insulin pump
  - when the blood sugar is increasing, a small correction bolus can be automatically delivered and a higher basal rate can be set

– when the blood sugar is decreasing, the basal rate can be halted to deny the quantity of insulin needed to bring the blood glucose level back up until the basal rate can be continued at a new lower rate;

- with adaptive filtering techniques, the pump can "learn" the unique basal rates for the person as a function of the time of day

Automated insulin pump for bolus control

• Closed loop can still correct a meal bolus error that was too large or small for the food consumed by:

- recognizing an imbalance between the bolus "insulin on board" and the level of blood glucose,
- automatically bolusing to correct a shortage of insulin, automatically reducing or interrupting the basal rate to correct an abundance of insulin,
- using adaptive filtering techniques to "learn" the carbohydrate to insulin ratios for each meal bolus


Thanks