Perioperative Management of Type 1 Diabetes and Insulin Pumps

PRESENTED BY CHELSEA HUBBARD RN BSN NAR

SAMUEL MERRITT UNIVERSITY

CLASS OF 2023

Presentation Outline

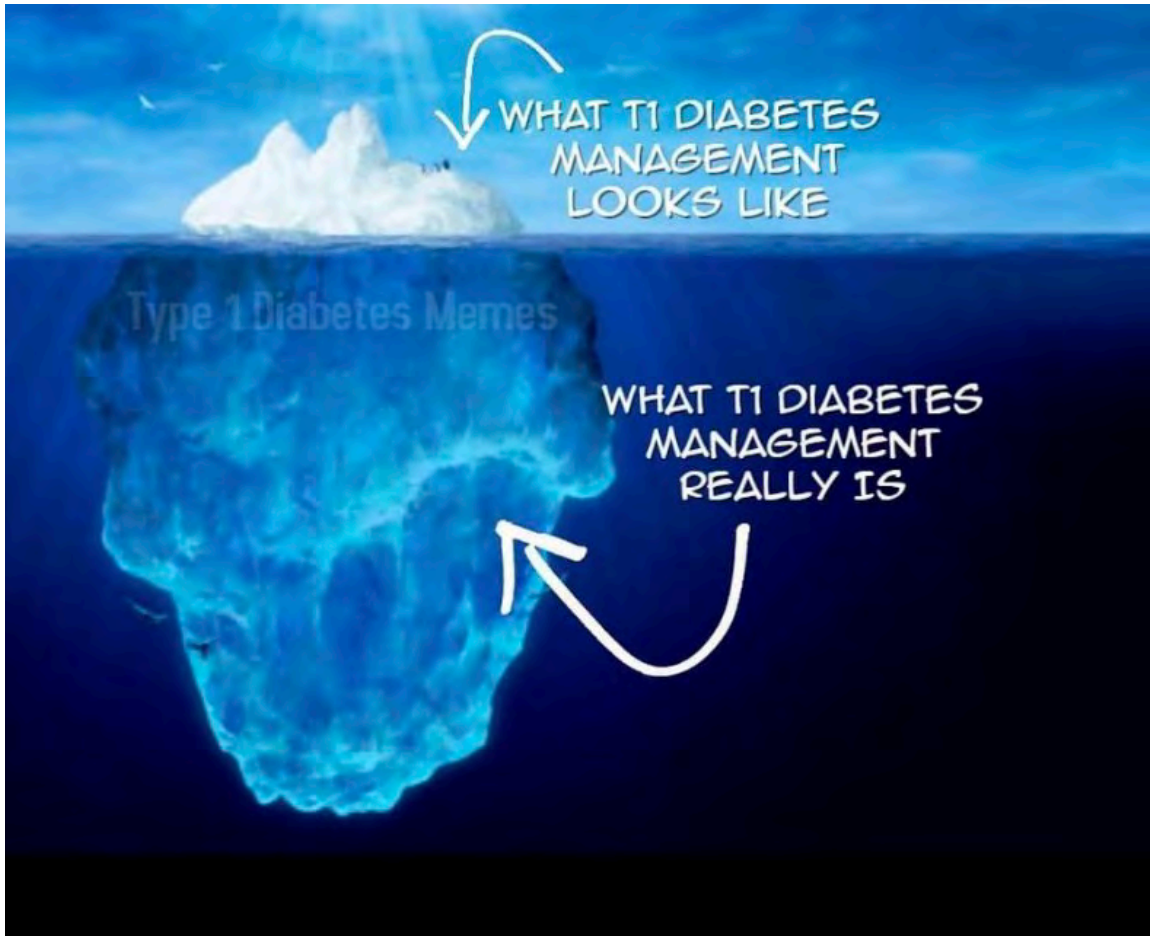
- **Review of Type 1 Diabetes**
- Difference between insulin injection and insulin pump therapy
- Integrated pumps
- Glycemic control in the OR
- Insulin pumps in the OR
- What to do if you stop the pump
- Best practices for using pumps perioperatively
- Case studies

Review of Type 1 Diabetes

- Glucose
  - Fuel
  - Component of Osmolality $\rightarrow\rightarrow\rightarrow$ $(\mathrm{Na}\cdot 2)+\left(\frac{glucose}{18}\right)+\left(\frac{BUN}{9}\right)$
  - Glycogenolysis, gluconeogenesis
- Insulin
  - Hormone
  - Beta cells of pancreas
  - Primary mechanism for glucose transport into cells

Review of T1D

- Destruction of beta cells resulting in absence of insulin production
- Lack of insulin leads to:
  - Hyperglycemia
  - Ketones
  - Acidosis
  - Death



Insulin Needs

- We ALL need insulin for TWO reasons
  - **PRANDIAL**: Pancreatic beta cells secrete insulin so we can utilize carbs we consume
  - **BASAL**: ***constant*** insulin secretion to meet metabolic needs. Metabolic insulin needs vary immensely from person to person and change throughout the day depending on activity, stress, hormones, etc.
- Type 1 Diabetes Mellitus – we supplement insulin for THREE reasons
  - **PRANDIAL**: Fast acting insulin at time of carbohydrate consumption
  - **BASAL**: Continuous "basal" level of insulin to meet metabolic needs.
  - **CORRECTION**: Additional insulin needed if BG is high (usually because basal or prandial insulin was insufficient)

RULE #1:
Never withhold basal insulin from patient with T1DM (unless they are hypoglycemic)

"Basal insulin is *mandatory* to prevent ketoacidosis in patients with Type 1 Diabetes and should not be withheld even in the fasting state"

- Leung & Ragbir-Toolsie 2017

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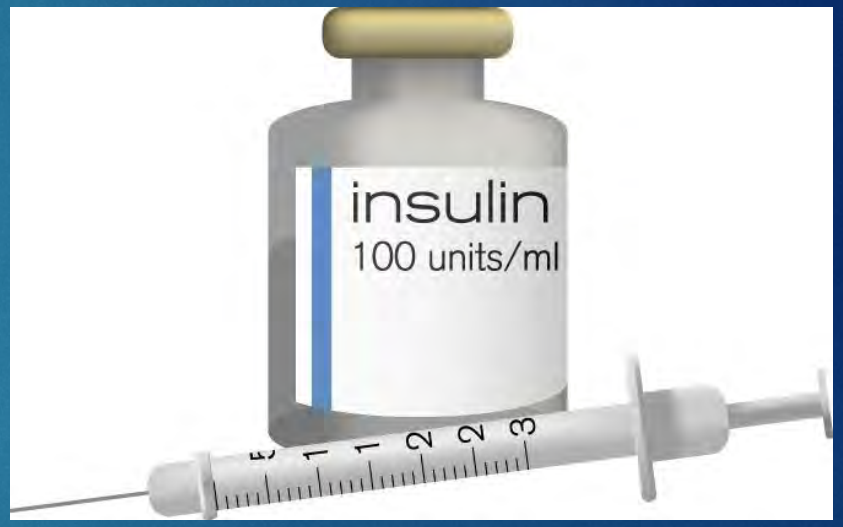
Injection vs Pump

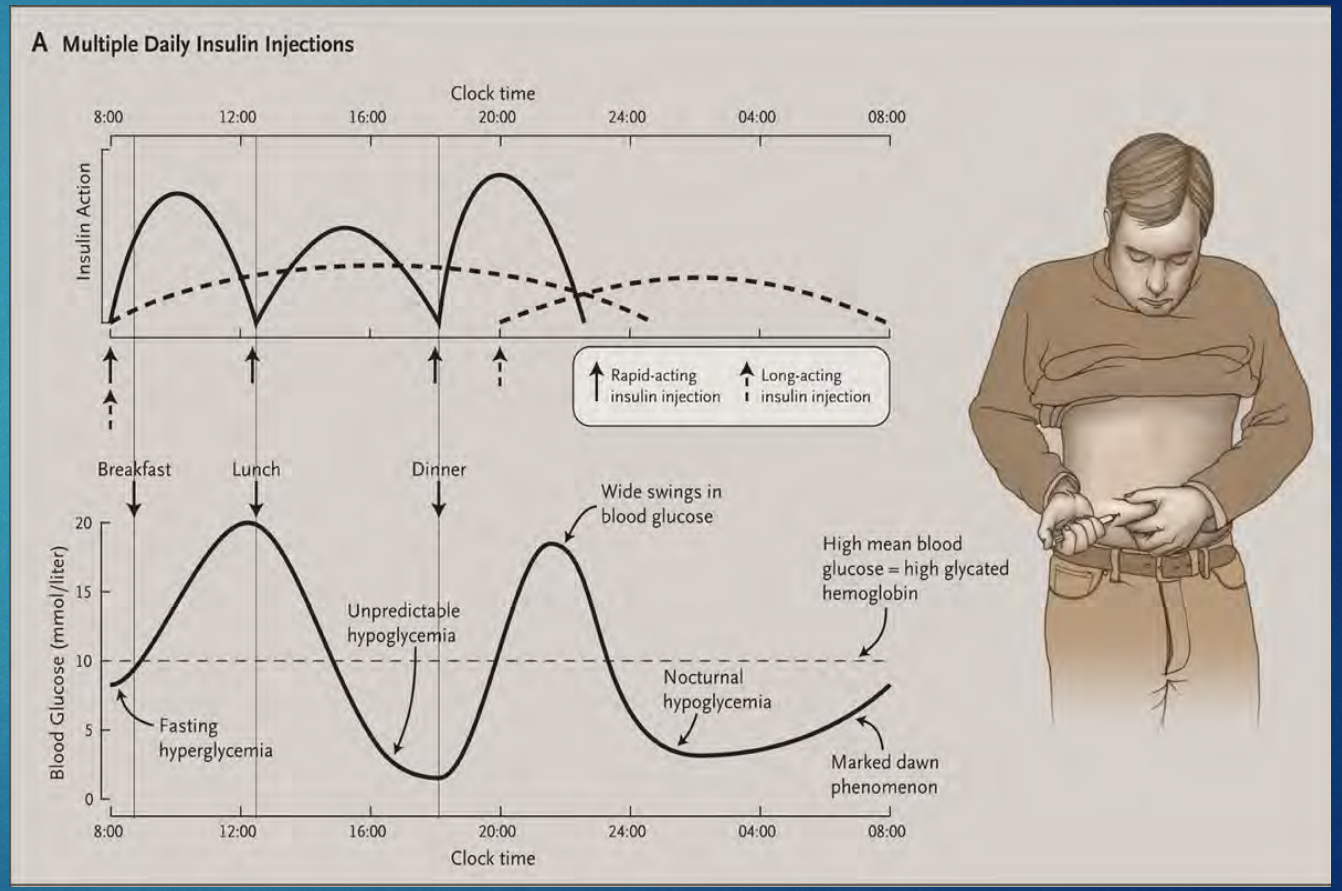
- Injectors use 2 types of insulin:
  - Fast acting insulin for prandial needs (meal coverage) and correction of hyperglycemia
  - Long-acting insulin for their "basal" needs.

- Pumpers use 1 type of insulin
  - Fast acting insulin is used to bolus for meals or correct hyperglycemia
  - Fast acting insulin is ALSO used as a slow continuous infusion to account for basal needs.
    - Because it is fast-acting, the basal rate can change to account for changes in metabolic needs



Glycemic control with INJECTIONS:

- Requires long-acting insulin
- Large glycemic variability is difficult to avoid



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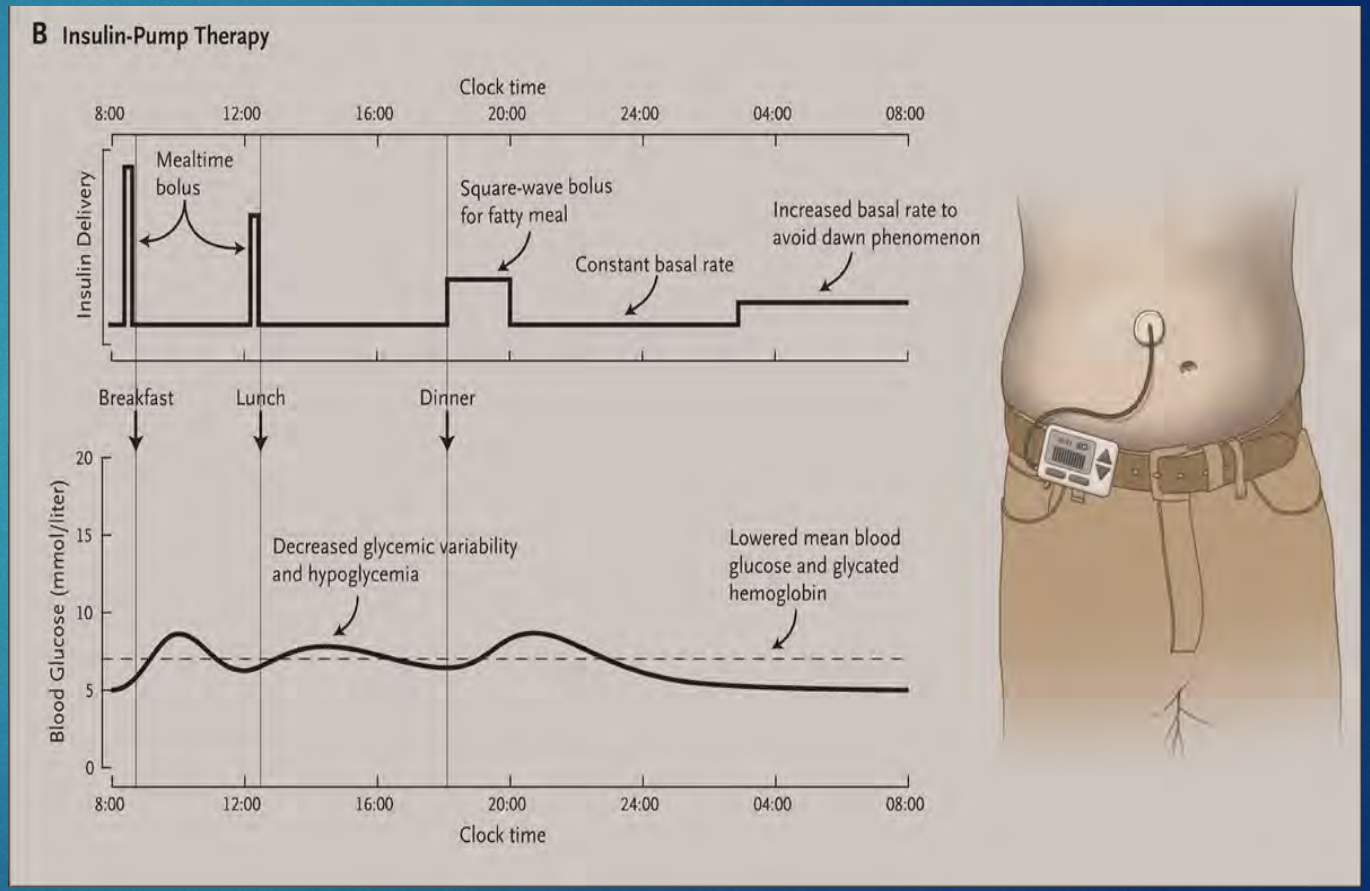
Glycemic control with PUMP:

- Less glycemic variability



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2 types of pumps:

- Stand alone pump (Open Loop)
  - Input BG and carbs at mealtimes.
  - Fixed basal rates are programmed into the pump. Can be manually adjusted based on observed trends to try reduce highs and lows.
- Integrated insulin pump (Closed Loop)
  - First closed loop pump was FDA approved in 2017.
  - Still input carbs at mealtimes.
  - Receives glucose level information from a continuous glucose monitor (CGM) and auto-adjusts basal insulin to maintain BG in range based on a complex algorithm.

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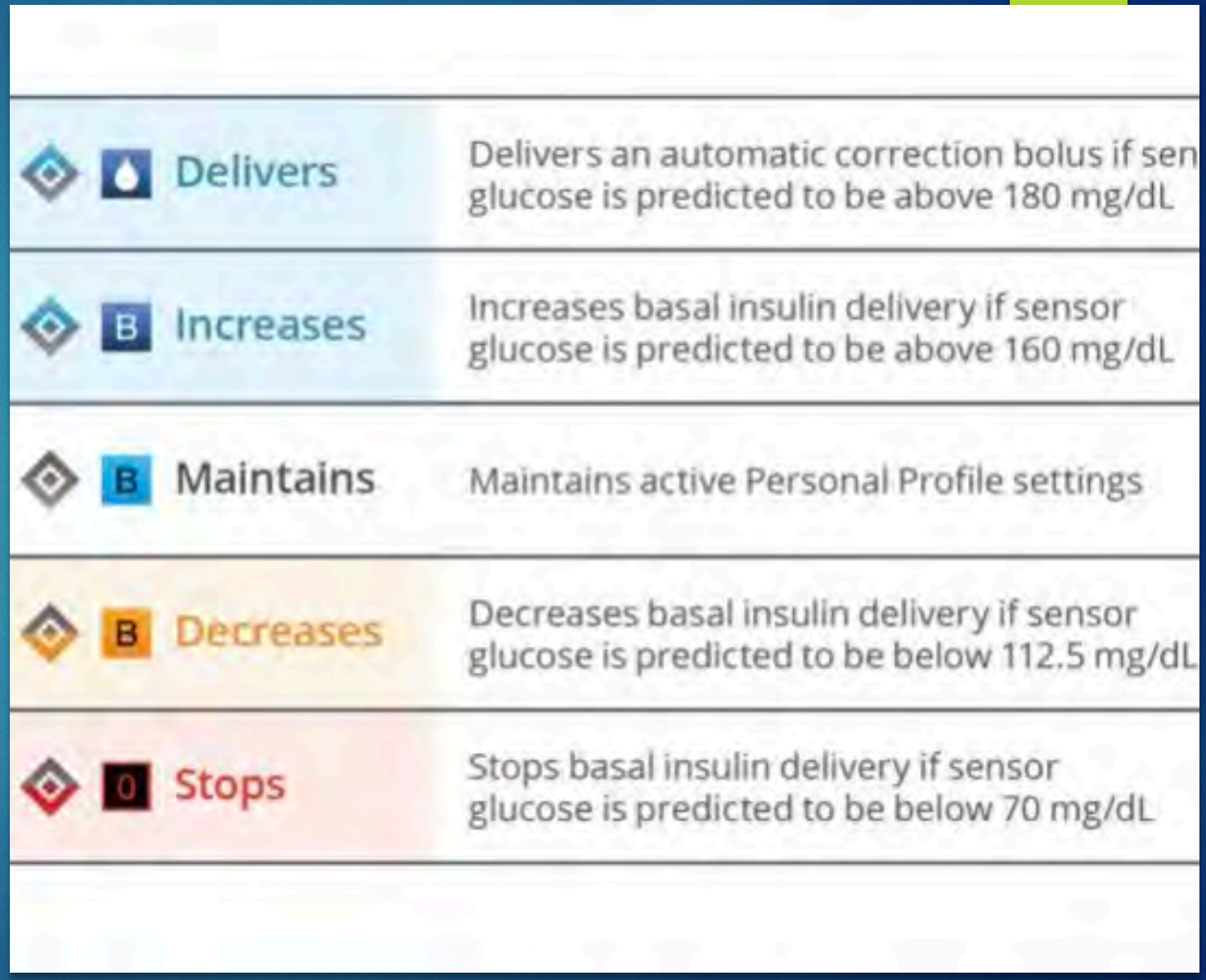
Integrated Insulin Pumps

- Aka “closed loop”
- Connect to a Continuous Glucose Monitor (CGM) that reads interstitial glucose levels
- Auto-adjust basal insulin based on glucose trends to maintain blood glucose within a ”target” range.
- Calculate mealtime doses based on carbs entered, taking into account ”insulin on board” (active insulin in blood stream from prior insulin boluses)
- Predict BG 30 min out
- Study BG trends - get smarter over time
- Alarm for highs and lows, both current and PREDICTED

Tandem

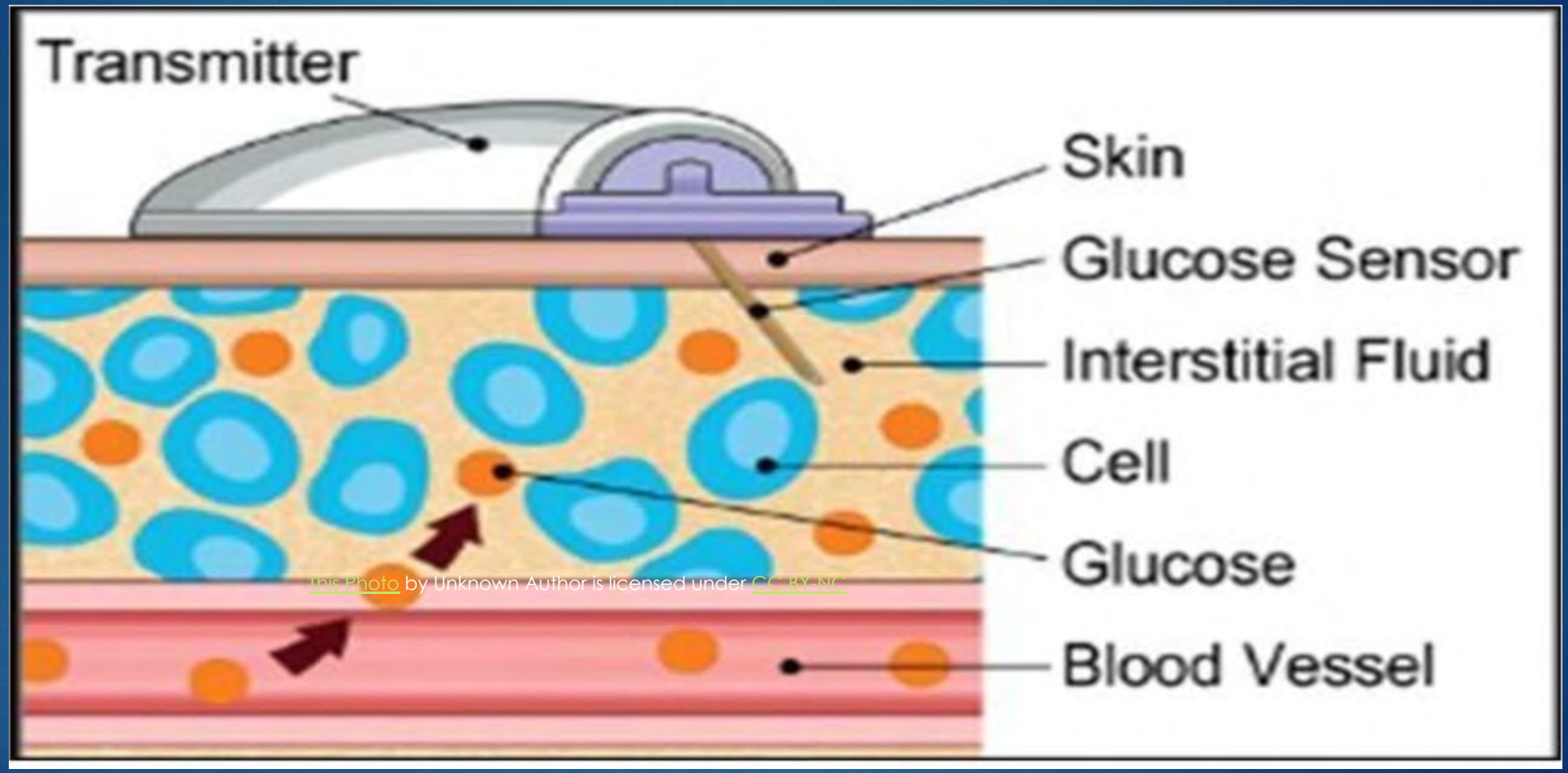
- Aka T-Slim
- Commonly paired with Dexcom G6 CGM
- “Control IQ” algorithm
- Effective at lowering A1C and maintaining glycemic stability
- ”exercise” and “sleep” features



Continuous Glucose Monitors

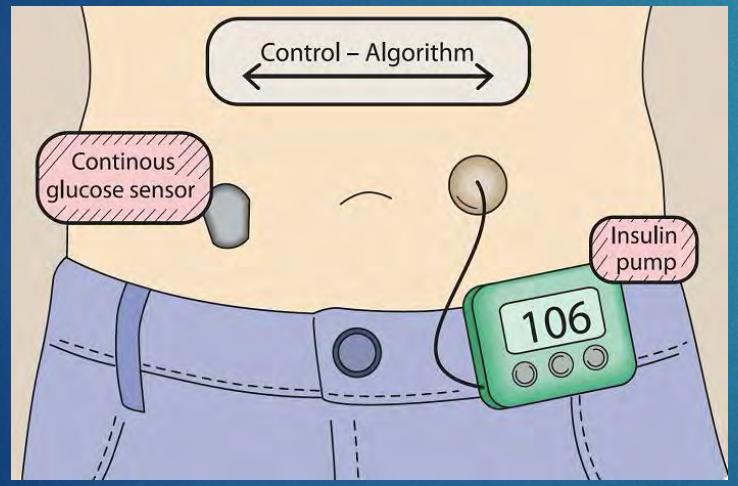
- Monitor interstitial fluid glucose every 1-5 min (Dexcom 5 min)
  - Different from blood glucose
  - 10-15 min lag time
- Display current glucose level AND trend AND rate of change
- Can stand alone or be connected to insulin pump.
- Accuracy: POC glucometers are 95% accurate; inpatient CGMs are 85-90% accurate
  - Less accurate outside 40-500 mg/dL, severe anemia, vasopressors
- Heparin, mannitol, dopamine, can lead to falsely high readings

Continuous Glucose Monitors



Tandem and Dexcom Systems

Limitations for pumps and CGMs



- Not truly an artificial pancreas! Still needs monitoring.
- Pump can "fail" d/t tubing occlusion, resistant tissue at insertion site, canula kinked, insulin denatures
- Recognition of pump failure: increasing glucose values despite presence of pump.
  - Assume for pump site failure
  - Switch to continuous IV insulin ASAP
- Pump or CGM on surgical site must be removed. Offer to patient
- Certain medications, electrocautery, and low perfusion states interfere with CGMs
- Not MRI compatible

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Glycemic control is complex under ideal circumstances

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Factors That Affect BG

Food
- ↑↑ 1. Carbohydrate quantity
- →↑ 2. Carbohydrate type
- →↑ 3. Fat
- →↑ 4. Protein
- →↑ 5. Caffeine
- ↓↑ 6. Alcohol
- ↓↑ 7. Meal timing
- ↑ 8. Dehydration
- ? 9. Personal microbiome

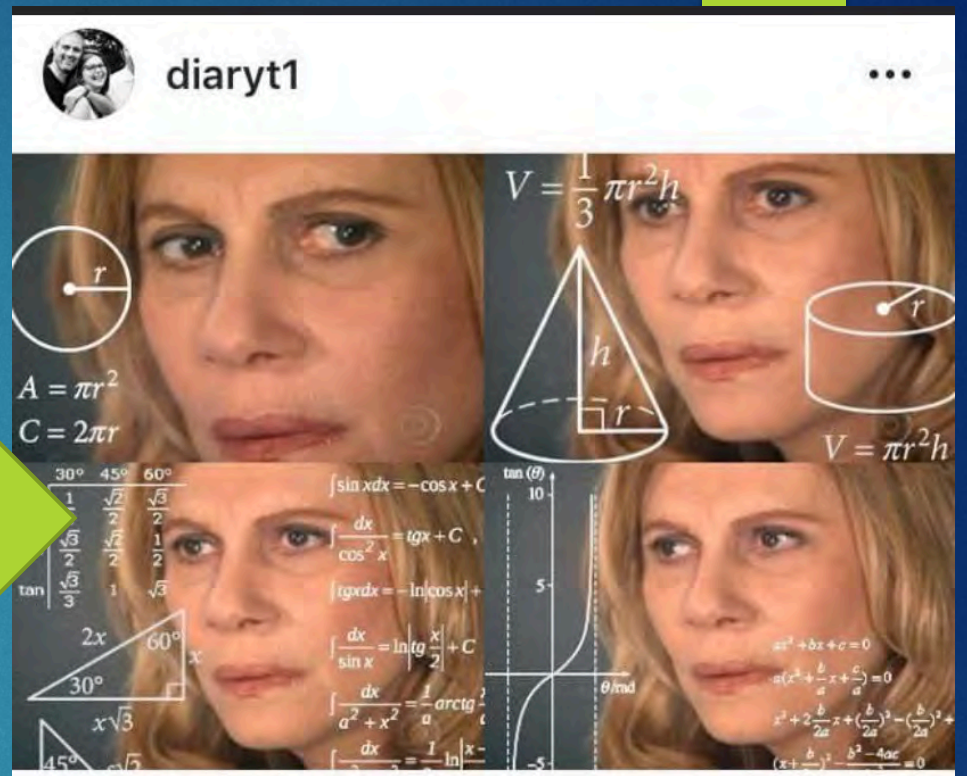
Medication
- →↓ 10. Medication dose
- ↓↑ 11. Medication timing
- ↓↑ 12. Medication interactions
- ↑↑ 13. Steroid administration
- ↑ 14. Niacin (Vitamin B3)

Activity
- →↓ 15. Light exercise
- ↓↑ 16. High-intensity and moderate exercise
- →↓ 17. Level of fitness/training
- ↓↑ 18. Time of day
- ↓↑ 19. Food and insulin timing

Biological
- ↑ 20. Insufficient sleep
- ↑ 21. Stress and illness
- ↓ 22. Recent hypoglycemia
- →↑ 23. During-sleep blood sugars
- ↑ 24. Dawn phenomenon
- ↑ 25. Infusion set issues
- ↑ 26. Scar tissue and lipodystrophy
- ↓↓ 27. Intramuscular insulin delivery
- ↑ 28. Allergies
- ↑ 29. A higher glucose level
- ↓↑ 30. Periods (menstruation)
- ↑↑ 31. Puberty
- ↓ 32. Celiac disease
- ↑ 33. Smoking

Environmental
- ↑ 34. Expired insulin
- ↑ 35. Inaccurate BG reading
- ↓↑ 36. Outside temperature
- ↑ 37. Sunburn
- ? 38. Altitude

Behavioral & Decision Making
- ↓ 39. Frequency of glucose checks

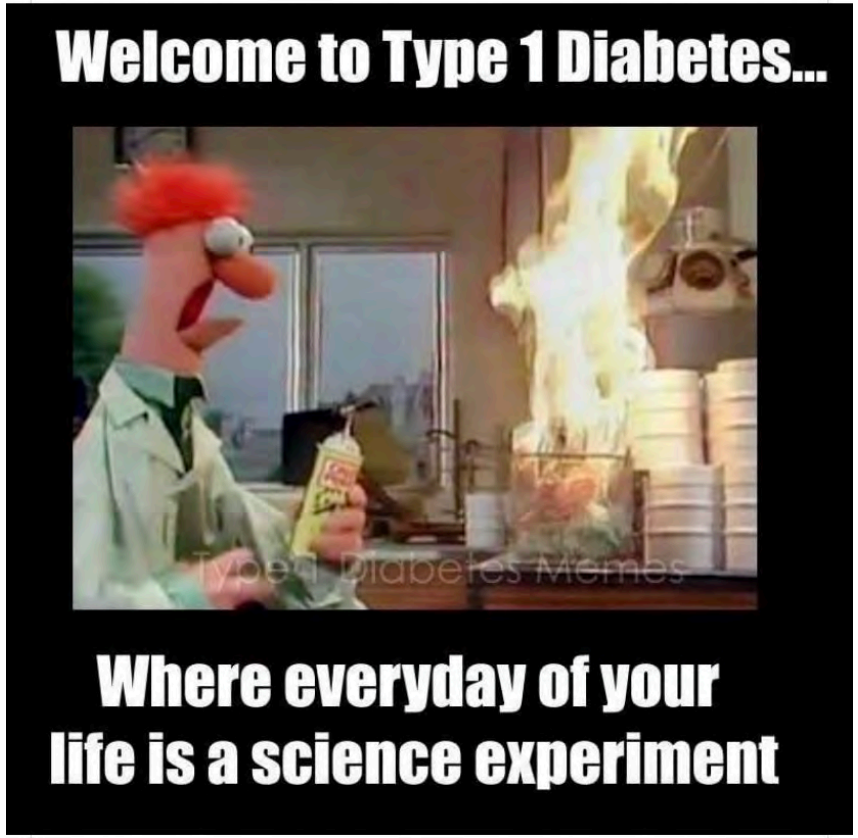


Intraoperative Effect on Blood Glucose

Perioperative state alters glucose homeostasis d/t:

Altered insulin response (resistance)	SNS stimulation •Preoperative anxiety •Intraoperative stressors	Medications (steroids)

What glycemic imbalance do these changes favor?



Intraoperative Glycemic Control

Intraoperative glycemic range: 140-180 mg/dL

Hyperglycemia:

- Causes fluid/electrolyte shifts, impaired immune function, increased viscosity.
- Worsened morbidity/mortality, SSI, pneumonia, impaired tissue perfusion (worsened ischemia in brain/heart/kidneys), longer LOS
- 25% of T1DM laparoscopic bariatric surgery developed ketones. (Aminian et al, 2016)

Hypoglycemia:

- Complications: seizure, death
- NICE-SUGAR study (2009) showed tighter glycemic control (81-108 mg/dL) resulted in higher incidence of hypoglycemia but no incidences of death in ICU patients.

What do the experts say?

"The results of our study confirm the association between increased length of hospital stay and risk of hospital complications and mortality in patients with blood glucose levels >150 mg/dl"

- Frisch et al., 2010

"Moderate glycemic control of [140 to 180 mg/dL] appears to be the best compromise resulting in a decrease in morbidity and mortality without increasing the frequency of hypoglycemia. Maintaining stable blood sugar levels between 140 and 180 mg/dL requires complex protocols employing IV insulin and these are difficult to execute in the absence of a computer program."

- Cheisson et al., 2018

Insulin is wild, because too much will kill you and not enough will kill you and when you're like 'wait, what's the right amount?' Your body's like 'it's a secret'

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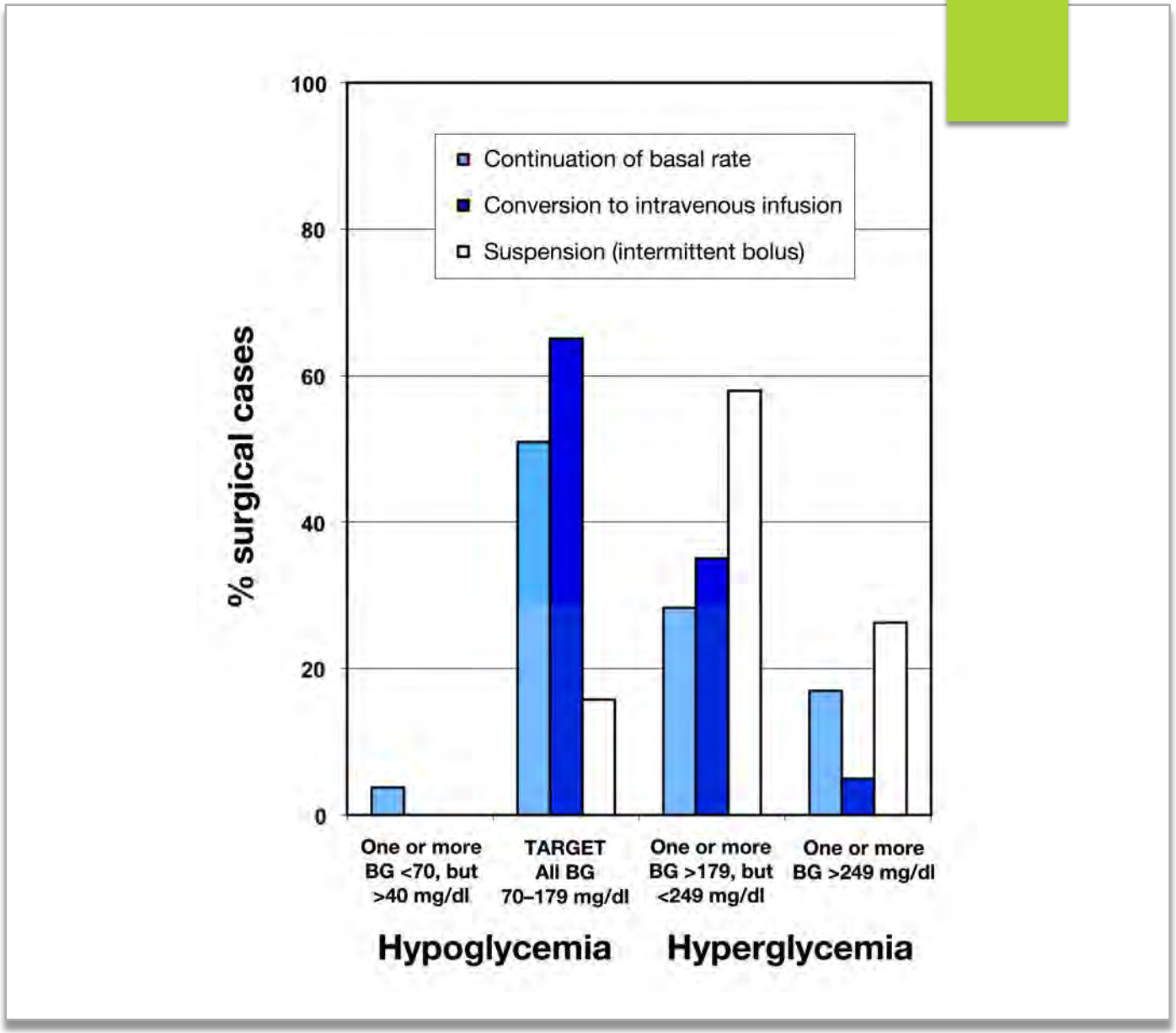
Insulin Pumps in the OR

- Sobel, et al., 2015
- Study of 49 subjects with insulin pumps undergoing 57 elective surgical procedures
- Purpose: identify safety and efficacy of insulin pumps
  - Safety events defined at BG < 70 and/or pump incidents
  - Efficacy defined as post op BG < 200
- Results:
  - Safety: no hypoglycemic events occurred
  - Efficacy: 63% < 200
- Conclusion: insulin pumps provide both safe and effective intraoperative glycemic control.

Insulin Pumps in the OR

- Corney, et al., 2012
- Compared intraoperative glycemic control between 3 groups:
  - Kept pump on (light blue)
  - Stopped pump, switched to IV infusion (dark blue)
  - Withheld basal insulin (white)
- Findings:
  - The majority of cases who stayed in target (70-179 mg/dL) were converted to IV infusion.
  - The majority of cases with severe hyperglycemia were those who did not receive basal insulin



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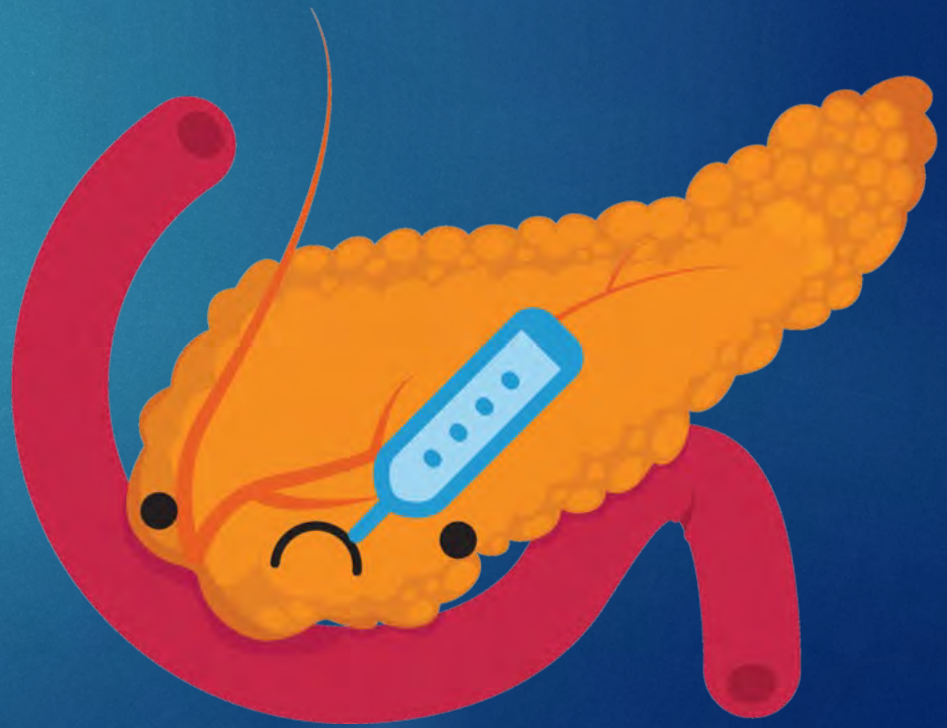
What if you can't use the pump?

- #1 rule of T1DM = never withhold basal insulin unless hypoglycemic
- If a T1DM patient must be disconnected from their pump and has no long-acting insulin, ALWAYS start continuous insulin infusion to prevent the development of ketones
- What insulin infusion rate should you use?
  - Profile settings in pump
  - Endocrinology note
  - Institution's policy



Pump vs Infusion

Advantages of pump

- Tighter glycemic control (closed loop)
- Pump knows patient's metabolism (closed loop)
- Can deliver smaller, more precise dosing
- Pump alarms can alert provider to dangerous glycemic levels
- Patient experience

Disadvantages of pump

- Potential for pump/CGM failure
- Some facilities require biomed evaluate/approve medical device (might delay procedure significantly)

Advantages of IV infusion

- More secure insulin delivery, no concerns of pump malfunction
- Don't have to involve biomedical engineering

Disadvantages of IV infusion

- Glycemic control not as tight
- Provider is guessing at dosing
- Not as precise
- Blood glucose is only evaluated every 30-60 min
- Some patients may prefer to keep pump on

Either way, blood glucose needs to be checked at least every 60 minutes perioperatively

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Best Practices

- Maintain BG < 180 mg/dL
- **Never withhold basal insulin from the patient with T1D unless hypoglycemic**
- Assess CGM preoperatively by comparing to FSBG
- Assess location of pump site and CGM site.
  - When was the device placed and when is it due to be changed? A device that was freshly placed or near-due to be changed may be less reliable.
  - Can't be on surgical site, ideally not on tissue that will be dependent and compressed during surgery
  - If using pump/CGM, make sure it is accessible during surgery
- Have patient show you basal settings in pump for reference in case you switch to IV insulin infusion
- Check blood glucose at least q 1 hour regardless of CGM or method of insulin delivery, more frequently if using CGM and electrocautery is used
- Consider disconnecting the pump and/or CGM if
  - The device is on the surgical site (patient might be able to place a new device in a different location)
  - Device has a metal needle and electrocautery will be used
  - Conditions that alter perfusion such as shock and vasopressors
  - MRI environment
  - Severe dysglycemia (suspicion of pump failure)
- If pump is stopped for ANY reason, start an IV insulin drip. Refer to pump settings and/or endocrinology for insulin drip dosing.

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Two Case Studies

- 56 yo M, type 1 DM "noncompliant", LVEF 30-40%, hx MI, CABG, multiple stents, ischemic cardiomyopathy, CRI Stage 3b, beta-blocker, hospitalized w acute on chronic resp failure
- presenting for podiatry procedure under MAC
- A1C: 6.8 (1 month preop)
- Preop BG: 140 per CGM
  - Pump taken off pump, wasn't permitted to bring phone (CGM receiver)
- Intraop BG: not checked
- Post op BG: 261
- Woke with radiating L jaw pain which pt reported happens with high BG
- SL NTG x 3, sliding scale insulin, EKG,
- 2 hrs later BG 332, "blood glucose continuing to climb despite insulin". Next BG 348
- Why didn't the BG respond to the insulin?

- 54 yo M, type 1 DM, "poorly controlled", HTN, beta blocker, CAD, CRI Stage 3b, EF 65%, hx stroke, hyperkalemic 5.9, hospitalized for acute on chronic renal failure
- presenting for podiatry procedure under MAC
- AIC: 8.5 (2 months preop)
- Preop BG: 123 per CGM
  - Kept on Tslim pump in Control IQ
- Intraop BG: 121 – 125
- Post op BG: 119
- Euglycemic throughout perioperative period

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