bcdiabetes.ca
Patient Care + Research + Clinical Trials

Tom Elliott MBBS FRCPC
Dae-Won (David) Lee MD FRCPC
Sarpreet Sekhon MD FRCPC
Clare Henderson MD FRCPC
Dale Clayton MD FRCPC
Georges Argoud MD ABIM
Meiying Zhuang MD FRCPC
Fatema Abdulhussein MD FRCPC

400 - 210 W Broadway, Vancouver, BC V5Y 3W2, Canada
phone: 604.683.3734 fax: 604.628.3821 email: moa@bcdiabetes.ca

insulin management in pregnancy, including AID

primary author Dr. Kate Hawke, BCDiabetes Technology Fellow 2023-2024, now practicing at Logan Hospital in Australia

1) Resources
   a) Expected trend in insulin requirements
   b) General factors that affect blood glucose
   c) Top tips video (covers diet recommendations, pre-bolusing)
   d) Info for patients https://bit.ly/BCDDiP
   e) Carb counting app, Dosing for fat & protein
2) CGM
   a) Set Display settings to 3.5-7.8mmol/L (instead of 3.9-10mmol/L) [1]
   b) Set high alerts at 8-9mmol/L
3) Diet & bolusing

- Recommend dietician referral, in 2023-24 have been referring to St Paul's dietician via https://diabetes.providencehealthcare.org/sites/diabetes.providencehealthcare.org/files/3934%20%28DB145%29%20Diabetic%20Health%20Centre%20Referral%20%28R.%20Feb%204-21%29fillable.pdf
   a) Low GI carbs, aim ~150g daily
   b) High protein/high fat meals help mitigate prandial spike
   c) Carb counting accuracy
   d) Early bolusing pre-meals [2]
      i) Trimester 1: 15min, Trimester 2: 20-30min, Trimester 3: 30-45min [2]
      ii) While pre-bolusing is important, consider how it interacts with loop system (is it resulting in a basal suspend prior to eating?)
   e) Maintain hydration

4) Hypoglycemia
   a) Generally, less hypo treatment is required with closed-loop (system will have already backed off on insulin; a full hypo treatment will likely cause a high)
5) Bolusing – corrections
   a) Correct for hyperglycemia carefully (no more than 2 hourly, depends on system)
6) Safety
   a) Be diligent with usual precautions for pump failure plan, sick day management, ketone testing, glucagon
7) Skin reactions to adhesives [3]
   a) Can occur do novo in pregnancy
   b) Option: apply devices to clean dry skin, without alcohol, to keep skin's natural barrier intact
   c) Option: when removing devices make sure to clean thoroughly and remove any residual adhesive (e.g. washcloth with warm water and olive oil)
   d) Option: see recommendations here: https://www.dexcom.com/faqs/sensitive-skin
8) Exercise
   a) Some people find a short walk post-meal to be helpful for prandial spikes
9) Pump [3]
   a) Many people find it helpful to change the pump site every 2 days instead of 3 (fresh site seems to work better with skin tissue changes in pregnancy)

b) Can write a prescription for pod change every 2 days due to insulin requirements
c) Many people find the effectiveness of some pump sites change from pre-pregnancy e.g. no longer as effective on thighs

Trimester 1 guide

1) Change glucose targets to pregnancy targets (if not done preconception)
   a) Generally use the target values around 5.5mmol/L; 5.0mmol/L if not having significant hypoglycemia
2) Pre-bolusing: 15 minutes pre-meal
3) Increased hypo risk
   a) Lower basals required
   b) 10-30% reduction in insulin dose between GW6-8 and GW10-14 can occur
   c) Review pump suspends (zero temp basal) – safety vs instability
   d) Ensure hypo management strategies, driving & glucagon reviewed
4) Manage nausea & vomiting
   a) Dietician support; small frequent meals
   b) Pharmacotherapy - pyridoxine/doxylamine is category A
5) Glycemic variability
   a) Some people need to change temp basal / temp profiles between 70% to 130% depending on the day (via a Custom Preset in Loop, or a profile switch temporary % in AAPS)
   b) Add bedtime snack

Trimester 2 guide

1) Pre-bolusing: 20-30 minutes pre-meal
   a) Some have benefited from giving two thirds of the carb entry bolus ~30-40min pre meal, and the remaining on third of the carb entry bolus ~10min pre-meal (ratio needs to be personalized)
2) Increasing insulin resistance
   a) ICR strengthening required, change by 10% at a time, may reach 3-4x early pregnancy doses
   b) ISF strengthening required, change by 10% at a time, may reach 1.5-2x early pregnancy doses
   c) Proportion of total daily insulin coming from boluses will be higher (>60%)
3) How to improve postprandial hyperglycemia
   a) More aggressive changes to bolus doses in Trimester 2
   b) Faster insulins
   c) Pre-bolus meal insulin
   d) Meticulous attention to carb count; may need protein & fat count also
   e) Low GI foods, high fat/high protein meals to help slow glycemic peak
   f) Can be helpful to space meals
   g) Use 'boost' or 120% temporary profile post-meal if high / anticipated high see this youtube segment on Looping in pregnancy in Kate Hawke's "AID for endocrinologists"
   h) Some people inject (MDI) for the meal outside of the pump. Option (a) declare the external insulin & carbs to the Loop. Option (a) is preferred. Option (b) do not declare the insulin & carbs to Loop, and let Loop handle the post-meal variability with micro-boluses (NB option b will alter the logged TDD from the true TDD; depending on AID algorithm, this may impact on future treatments)
   i) Encourage physical activity for ~15 minutes after meals.
4) Consider using U200 insulin for high requirements [3], see U200 transition
   a) Can help with issues of bolus size (larger boluses more poorly absorbed and take quite a long time for the pod to actually push through), and with duration of pod wear when on high TDD (NB some people still find it helpful to change pod 2nd daily rather than 3rd daily due to 3rd-day-absorption problems)
   b) U200 humalog (lispro)
   c) When transitioning to U200, all pump settings need to be cut in half, see U200 transition
      i) E.g. for basal, 1.4 units/hr (of U100) changes to 0.7 units/hr (of U200).

ii) E.g. for carb ratio, 1:4-1:5 g changes to 1:8-1:10g

d) For the transition period, go into Open Loop for ~4 hours (if remaining in Closed Loop, system may think that IOB is more than it actually is)

e) Once on U200 and making setting adjustments, go by half the strength of usual. E.g. if you would usually strengthen (lower) the carb ratio by 1, strengthen it by 0.5. Appropriate to use 10% changes e.g. from 8 to 7.2.

f) Never override the pump when using U200 i.e. don't give a fixed bolus (e.g. 8 units) as you will get double (16 units).

Trimester 3 guide

1) Pre-bolusing: may be up to 30-40 minutes pre-meal for some people
2) Ongoing changes to settings often required until ~GA 36, then typically plateau
   a) Proportion of total daily insulin coming from boluses will be higher (often 70%)
3) A *reduction* in requirements of >10% should prompt clinical review and consider assessment for placental insufficiency
4) Ensure peripartum insulin planning documented from GA 30, communicate plan to patient & care teams (written & verbal)
5) If using U200, consider switching back to U100 before planned birth, see U200 transition - this will avoid confusion and potentially dangerous mistakes at the hospital, where other clinicians will be much more familiar with U100

Peri-partum guide - **see peripartum plans**

Post-partum guide

1) Much lower insulin requirements
   a) Typically 50-70% of the **pre-pregnancy doses**
   b) Some women need almost no insulin the first 24 hours
2) Risk of hypo with breastfeeding
   a) Take 10-15g uncovered snack with feeds (will need to assess how this works with AID, to ensure system doesn't give excess insulin to cover food)
   b) Apply an "exercise" custom pre-set, or temporary profile percentage to lower overall insulin [3]

AID in pregnancy

CamAPS in pregnancy (Ypsopump with myLifeLoop in Canada)

1) Webinar
2) CamAPS algorithm specifics
   a) Inputs during set-up: body weight, TDD. (ISF and AIT calculated by algorithm).
   b) Adjustable settings to optimise closed-loop: ICR, target (default 5.8mmol/L).
   c) Settings not affected closed-loop operation (active insulin time, insulin sensitivity, pre-programmed basal rates). Still important to have these accurate in the event of open loop (e.g. sensor warm-up). Update basal rates 4 weekly.
3) Suggested algorithm targets in pregnancy:
   a) Trimester 1: 5.5mmol/L
   b) Trimester 2 (or earlier if hypo risk low): 4.5-5.0mmol/L
   c) Can use a tighter target overnight
   d) Target to 5.8mmol/L if frequent hypos; only for few days then return to tighter target
4) Basal rate & weight adjustment
   a) Weight should be updated on the app 4 weekly
   b) As TDD increases, remember to increase max bolus and daily max in doctors mode
5) Ease off

a) Substantially reduces basal insulin delivery; raises glucose target temporarily; insulin delivery stops if glucose <7mmol/L
b) Use for exercise, following hypo, hot weather

6) **Boost** – like a smart temporary basal
   a) Increases basal insulin delivery by ~35%; once glucose reaches target, boost will not continue to increase insulin delivery
   b) Use for post-prandial hyperglycemia; low grade illness (not requiring sick day rules)
   c) Used almost ubiquitously post-meal from about GA12-14 at least once or twice a day
7) Hypoglycemia treatment
   a) when treating a low, enter carb amount under "Add Meal" > "Hypo Treatment"
8) Pre-bolusing
   a) Pre-bolus of 10-15 minutes appropriate throughout pregnancy; typically don't need the long 30-40min pre-bolus in late pregnancy with the CamAPS system (ultra-early pre-bolusing will cause the system to back off on insulin during the re-bolus period)
9) Sets
   a) Change set closer to every 2 days later in pregnancy (algorithm learning will be poor if the 3rd day has very different absorption)
10) Steroids
   a) Glucose target 4.5-5mmol/L
   b) Use boost +/- strengthen ICRs
11) Peri-partum
   a) Can remain in closed-loop during delivery provided they/partner can manage pump
   b) Consider placement of insulin pump (flank) for C/S
   c) Fasting: Raise target to 5.8mmol/L
   d) May suspend pump in OR if glucose <6mmol/L (suspend for 30-40min)
   e) Induction: could use ease-off during labour
12) Post-delivery
   a) Adjust ICR to pre-pregnancy ratios; increase target to 5.8mmol/L or 6mmol/L
   b) Glucose targets return to 3.9-10mmol/L
   c) Use ease-off for breastfeeding

Medtronic 780G in pregnancy [4]

1) Adjustable factors: target, AIT, carb ratio
   a) Ensure target is as low as possible (5.5mmol/L)
   b) Make AIT as low as possible – 2 hours
   c) Ensure carb ratio is adequate
2) Note that algorithm will aim to predict hypoglycemia in next 4 hours, and may give "safe bolus" i.e. lower bolus than planned based on carb ratio. *Sometimes need to enter 'fake carbs'*, 20 to 100% of the carbohydrates you will eat. [1]
3) Peri-partum
   a) Target to 6.1 or 6.7mmol/L
   b) AIT leave at 2 hours
   c) If trending to hypoglycemia, use temp target
4) Post-partum
   a) Change ICRs (make half as strong as during late pregnancy)
   b) Breastfeeding: use temp target

Tandem Control IQ in pregnancy [4]

- NB if using Control IQ pre-pregnancy, it is *not* possible to revert to Basal IQ (PLGS)

1) Adjustable factors: basal rate, ISF, ICR (not adjustable – target, IDA)

2) Target range:
    a) Sleep mode: 6.25 – 7mmol/L
    b) Usual: 6.25 – 8.9mmol/L
    c) Exercise mode: 7.9-8.9mmol/L
    d) Recommended pregnant patients to use sleep mode 24 hours a day, but NB the algorithm does not give automatic correction boluses when in Sleep mode – need to give manual correction bolus as required
3) Adjustments [1]
    a) Aggressive insulin adjustments required in comparison to standard pump adjustments, esp when insulin resistance starts – programmed basal rates 20-40% higher than what was actually delivered (patients do poorly with TIR if they are not keeping up with regular uptitrations of settings as you would do in open loop pump)
    b) ISF affects both correction boluses and basal modulation
    c) Use ISF at least as strong as 90 rule
    d) Use ICR at least as strong as 400 rule
4) Meal bolus
    a) Do not accept reduction of meal bolus (Control IQ bolus calculator offers reduction if glucose <6.1mmol/L)
5) Use fewer CHO for hypoglycemia tx (4-8g) as system is designed to avoid hypos more than avoid hyperglycemia
6) Ensure max bolus limits are set slightly above expected bolus doses (up to 25 units)
7) Peri-partum
    a) Start the "post-partum profile" when starting labor or 1 hour before planned C/S (Wang et al 2023)
    b) Sleep mode can stay on during labor & delivery (if trending low – turn it off)
    c) After delivery, stop sleep mode
    d) If trending low, or breastfeeding, use exercise mode

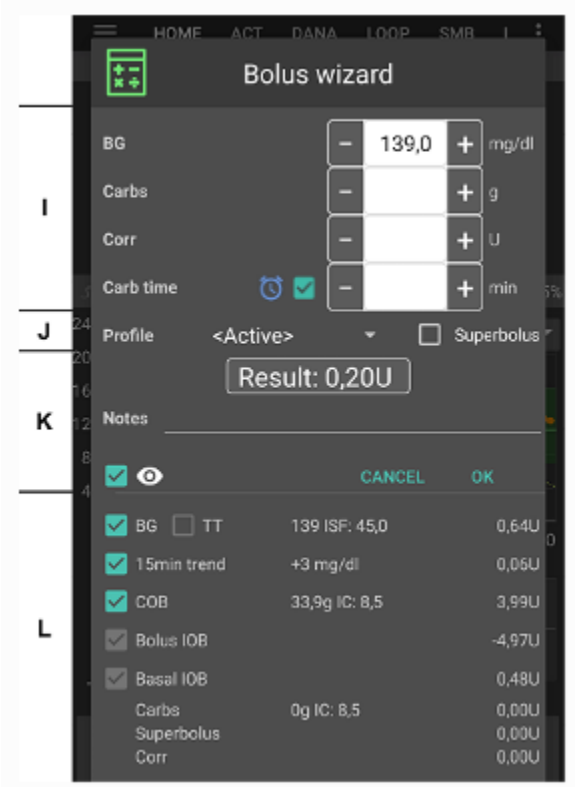
Loop in pregnancy see this youtube segment, part of Dr. Kate Hawke's "AID for endocrinologists" 55 min video

1) Adjustable factors: target, basal, ICR, ISF, glucose safety limit, pre-meal range
    a) Consider using the lowest Glucose Safety Limit of 3.7mmol/L [1]
    b) Consider using overnight targets of 5.0mmol/L or even 4.8mmol/L if stable and minimal hypoglycemia. We usually use a target of 5.0 mmol/L throughout the day.
    2) Hard maximums in Loop for Pregnancy
    a) Bolus = 25 units / max bolus limited by pump
    b) Max IOB = 2 x the max bolus (remember to increase max bolus & max basal progressively as required)
3) Meal absorption profiles:
    a) Typically avoid use of the 30 minute absorption profile. This tends to result in excessive basal suspends post-meal.
    b) As pregnancy progresses, some people need to use a longer profile to accommodate delayed gastric emptying. However in many patients the insulin resistance will be so profound that reduction of the upfront meal bolus is unhelpful.
4) Prandial highs
    a) As detailed above in general tips & trimester-by-trimester sections, post-meal boost is typically required to maintain robust insulin delivery by Loop (basal + auto-boluses) following meal boluses. In Loop this means a custom preset of at least 120% (and sometimes up to 200%), applied for 1-2 hours immediately post meal-bolus.
    b) Ensure ICR & ISF is being appropriately strengthened regularly.
    c) Consider activating the experimental Loop algorithm GBPA (glucose-based partial application), with which LOOP varies the percentage of microboluses (up to max 80%) at high glucose levels after meals.

5) Post-partum
    a) It is possible to have multiple profiles. BCDiabetes recommends setting up a postpartum profile before delivery and then activating post-delivery. BCDiabetes staff individualize the postpartum profile based on peripartum settings.

AAPS in pregnancy

1) Adjustable factors: target, basal, ICR, ISF, DIA, max SMB basal mins, Dynamic ISF [1]
2) 'Patient type' can be set to "pregnant" to allow higher Hard maximums for AAPS
    a) Max bolus = 60 units
    b) MaxIOB SMB = 70 units
    c) Max basal = 25 units
3) Prandial highs
    a) As detailed above in general tips & trimester-by-trimester sections, post-meal boost is typically required to maintain robust insulin delivery by Loop (basal + auto-boluses) following meal boluses. In AAPS this means a temp profile 120% strength, applied for 1-2 hours immediately post meal-bolus.
    b) Ensure ICR & ISF is being appropriately strengthened regularly.
4) "2nd bolus" for simultaneous carbs
    a) The way the AAPS algorithm handles "simultaneous carbs" (i.e. a 2nd carb bolus within a short period of time) is a little different. In general with the 2nd carb bolus, the *Bolus Wizard* will only recommend a very small amount of insulin upfront (or zero insulin). It is focused on the IOB and COB from the 1st carb bolus.
    b) If you proceed with administering the very small amount of insulin recommended by the *Bolus Wizard*, AAPS will generally give the bolus for the 2nd meal gradually over the next 30-60min as micro boluses (i.e. the system waits to see that your glucose is really rising from the 2nd meal, then starts to give the bolus gradually). This is a conservative approach that prioritises avoiding lows from a second "stacked" bolus.
    c) When aiming for tight control and/or with increasing insulin resistance, this approach by AAPS may be inadequate to cover the 2nd meal.
    d) You have the option to take the algorithm constraints off the 2nd bolus, and instruct the system to go ahead and give the full amount of insulin for the 2nd meal based on your carb ratio.
    e) The way to do this is to untick the boxes in the "L" section of the screenshot below:



f)

g) **Always review the "Result" before administering, and ensure that this is a reasonable insulin dose for you, factoring in all the usual considerations (current glucose, food intake, planned activity, etc).** You still have the option to adjust the wizard's recommendation manually using the "Corr" field in the top part of the bolus wizard. For your first few times taking the algorithm constraints off for a 2nd bolus, for safety you should consider doing a manual reduction in the bolus using the "Corr" field so that you get a sense of how the AAPS 2nd bolus behaves.

h) For more details on what each of the tick boxes represents, see the AAPS docs:

i) This strategy ONLY applies to 2nd boluses. The 1st bolus for a meal should always have the tick boxes ticked, as we want the AAPS algorithm to be doing the optimal "factoring in" of current glucose, glucose trend and IOB.

5) Peri-partum

a) Pre-set a post-partum profile in Android APS to use during/after delivery, see **peripartum plans**

References

1. Van Boxelaer I. How to Use Closed-Loop Systems in Pregnancy? 2023 [Available from: https://www.diabetotech.com/blog/how-to-use-closed-loop-systems-in-pregnancy.

2. DTN-UK A. BEST PRACTICE GUIDE: Using diabetes technology in pregnancy 2020 [Available from: https://abcd.care/resource/best-practice-guide-using-diabetes-technology-pregnancy.

3. DIY Looping in Pregnancy online forums (closed group) [

4. Technology in pregnancy - closed loop. International Association of the Diabetes in Pregnancy Study Groups; 2022; Sydney.