ACOI HOSPITAL MEDICINE COURSE

DIABETES GOALS IN THE HOSPITAL AND TREATING HIGH BG'S

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Hospital diabetes management

- General
- ICU
- Treating DKA/transition to regular hospital floor.
- Treating hyperosmolar non-ketotic hyperglycemia
- Pre-op/post-op
- Transition to home
- Home

Differentiate patients with type 1 from type 2 DM

What is the goal of inpatient DM management

- Provide safe use of diabetes medications
- Avoid significant hypoglycemia
- Attempt to keep BG near target range
- For well trained patients, give them an experience that is nearly equal to their own ability to care for the DM at home; for less well trained patients: train them and acknowledge that the diabetes is a major concern for them
- Can this be accomplished in a short hospital stay? Does it make a difference? Does it have to be done with insulin or intensive insulin therapy?

Target BG in hospital

- We do not have the perfect insulin and there are so many variables that perfection and consistency sometimes cannot be achieved at home or in hospital

(illness, variable absorption of meds and food, other meds, endogenous glucose production, etc.)

- Should all patients be on Basal insulin in hospital?
- Should all patients be on Lantus and Humalog in hospital?
- Can we learn to use it effectively (match it to carbs, etc)?
- Can we expect good BG control in a short hospital stay from an insulin regimen that takes weeks to months to adjust?

ASSESS DM STATUS

- Type of DM and A1c control
- Insulin deficient vs. insulin resistant or both
- Patient compliance and capabilities
- Cost issues
- When is BG is high (after meal vs. pre-meal or both)
- Duration of DM

TYPE 1 DM

1. Type 1 diabetes: will need basal insulin even if not eating.
2. Will need insulin with meals even it BG is not elevated.
3. People with type 1 DM tend to be more sensitive to insulin.
4. Use their home dose as a template to dose their hospital insulin doses.
5. TDD: 0.5 units/kg/day to start. About 1/3 to ½ of their TDD is generally rapid-acting insulin for meals.
6. Remember: the function of basal insulin is to control the hepatic production of glucose. If the Basal insulin dose is correct, the bedtime BG should be about the same as the next morning's fasting glucose (assuming no food or rapid-acting insulin at nighttime).

Basal Insulins

- Glargine (Lantus and Basaglar)
  -24 hour
- Detemir (Levemir): almost 24 hours
- Toujeo
  -concentrated glargine (U-300)
  -longer acting
- Degludec (Tresiba)
  -longer acting

BASAL INSULIN

- FUNCTION of basal insulin:

  -to counteract the hepatic production of glucose

If the BASAL dose is correct:

-HS blood sugar should roughly equal FBS (assuming no food or rapid-acting insulin in between)

-BG should be stable throughout the day, assuming no food, exercise

BASAL INSULIN

- If a patient has type 1 diabetes mellitus or is markedly insulin deficient, need to put on basal insulin even if not eating.
- If insulin pump is going to be removed for more than 24 hours, need to give basal insulin right away (don’t wait until HS)

Common errors in the use of basal insulin

- Adjusting it just based on the fasting glucose alone, with the goal of getting the FBS in range: very dangerous but common mistake
- Expecting basal insulin alone to do everything such as to control the blood sugar all day, even in very insulin deficient patient (many patients and all insulin deficient patients, will need basal-bolus insulin)

Common errors in the use of basal insulin

- Not using a pill or injection that specifically counteracts carbs, along with the basal insulin
- When the patient is intensified to multiple daily injections, not educating the patient to learn carb counting and a correction scale (or a simplistic version)
- Not giving any if insulin pump has to be removed
- Resuming an insulin pump before 20-24 hours following a shot of basal insulin (can do this if temporarily reduce the basal rate)

Common errors in the use of basal insulin

- Not further titrating the regimen after discharge.
- Assuming the hospital dose will be the outpatient dose and vice versa.
- Expecting basal insulin to be effective without prandial medication, especially in an insulin deficient patient.
- Expecting to have perfect sugars rapidly. These regimens take a while to titrate to effectiveness and the unpredictability of the hospital setting often precludes good control in the short-term with intensive insulin

Common errors in the use of basal insulin

- Not giving it when an insulin drip is stopped, along with rapid-acting insulin in a very insulin deficient patient or patient with type 1 DM

How can you tell if a patient is very insulin deficient?

- Longer duration of DM (10-15 + years)
- Thinner
- Very high A1c despite 2 or more oral medicines
- Type 1 diabetic

How can you tell if a patient is very sensitive to insulin

- Thinner patient
- Type 1 diabetic (often)
- Low dose of insulin at home (assuming reasonable A1c)

CAVEATS

- Patients with hypoglycemia awareness
- Titration at home after discharge
- Need a plan to get the patient on oral agents at home if insulin was just used per “protocol” in the hospital
- Patients with night-time peritoneal dialysis often are better off if put on NPH at nighttime (and possibly in the AM) along with possibly some rapid-acting insulin at HS.

CAVEATS

- Do not hold the basal insulin for procedures (if the patient is on an appropriate dose, it does not depend on food intake).
- Don’t adjust basal insulin day by day based on current blood sugar reading
- If FBS is not elevated, but A1c is high, basal insulin might not be a good choice. Instead, they might need rapid-acting insulin
- Do not titrate basal insulin just because the A1c is high without knowing when the BG is elevated

INTENSIVE INSULIN THERAPY

- Very user dependent, labor intensive, data driven to be successful, particularly in very insulin deficient patients
- Much match Rapid-acting insulin to carbs and be able to use a correction scale
- Insulin analogues are expensive

Limitations of intensive insulin therapy in hospital

- Cannot count carbs in hospital or at least cannot order rapid-acting insulin to be given based on a carb ratio
- Cannot alter rapid-acting insulin dose based on amount patient actually eats; but have to settle for giving Humalog after eating if not sure that patient will eat. Might have to give right after eating.
- If patient becomes more active, the Lantus or Humalog dose might be too much

Rapid-acting insulin analogues

- Humalog (lispro)
- Novolog (aspart)
- Apidra (glulisine)
- FiASP (aspart): more quickly absorbed than Novolog

- Pens versus vials and syringes
    - All are expensive if no insurance coverage
    - Some insurances cover one or two of these preferentially

Humulin R

- In Hospital, basically only for IV insulin drips
- Cheaper, so often use as an outpatient if patient has no insurance
- ?Patients with gastroparesis

Humulin R U-500

- 5 times concentrated.
- Best to use U-500 pens, which are calibrated to give the dose that is dialed up.
- If using vials, should use U-500 syringes (not the usual U-100 syringes)

R U-500 insulin SC

- CAUTION!!!
- Get pharmacist involved. Ideally, use R U-500 insulin pens, which are calibrated to give the correct dose in units.
- R-U-500 insulin is generally only used in the hospital if the patient is eating and is on hundreds of units of insulin daily and was on R U-500 at home.
- The home dose likely should be decreased as an inpatient: perhaps 20+% or more reduction.

Humulin N: intermediate acting insulin

- Inexpensive
- Peaks
- Reasonable if patient will not take more than 2 shots daily (especially if mixed with R)
- Used in pregnancy by most doctors (and probably in anticipation of pregnancy)

PRE-MIXED insulins

Simple regimens; if patient not compliant, if patient cannot use more intensive insulin or if patient is fairly regimented or if patient is doing well on this already. Can be very limiting and inflexible. More difficult to use in the hospital.

- Humulin 70/30
- Humulin 50/50
- Humalog mix 75/25
- Novolog mix 70/30
- Humalog mix 50/50

- Diabetes Care in the Hospital: *Standards of Medical Care in Diabetes—2018*
- American Diabetes Association
- Diabetes Care 2018 Jan; 41(Supplement 1): S144-S151. https://doi.org/10.2337/dc18-S014

ASSESS DM STATUS

- Type of DM and A1c control (initial orders should indicate if type pre-existing 1 or type 2 DM or if no previous diagnosis of DM.
- Insulin deficient vs. insulin resistant or both
- Patient compliance and capabilities
- Cost issues
- When BG is high (after meal vs. pre-meal or both)
- Duration of DM

- Perform A1c on hospitalized patients with DM or hyperglycemia if not done for 3 months or longer.
- Include Diabetes Self-Management Education
- Computerized order entry if developed.

- Insulin therapy should be initiated for treatment of persistent hyperglycemia starting at a threshold ≥180 mg/dL. Once insulin therapy is started, a target glucose range of 140–180 mg/dL is recommended for the majority of critically ill patients and noncritically ill patients.
- More stringent goals, such as 110–140 mg/dL, may be appropriate for selected patients, if this can be achieved without significant hypoglycemia.
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Target BG in hospital

- 140-180
- Dependent on age and health and risk of hypoglycemia
- Could shoot for tighter goals if on agents that do not cause hypoglycemia or in select patients without risk of hypoglycemia.

TARGET BG in Hospital

- However, less tight targets should be achieved for some patients who are terminally ill, have severe comorbidities, and in settings with limited BG monitoring and/or nursing care.

HYPOGLYCEMIA

- The hypoglycemia alert value in hospitalized patients is defined as blood glucose ≤70 mg/dL and clinically significant hypoglycemia as glucose values <54 mg/dL. Severe hypoglycemia is defined as that associated with severe cognitive impairment regardless of blood glucose level

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Target BG in hospital

- We do not have the perfect insulin and there are so many variables that perfection and consistency sometimes cannot be achieved at home or in hospital

(illness, variable absorption of meds and food, other meds, endogenous glucose production, etc.)

A meta-analysis of over 26 studies, including the Normoglycemia in Intensive Care Evaluation–Survival Using Glucose Algorithm Regulation (NICE-SUGAR) study, showed increased rates of severe hypoglycemia (defined in the analysis as blood glucose <40 mg/dL) and mortality in tightly versus moderately controlled cohorts.

Recent randomized controlled studies and meta-analyses in surgical patients have also reported that targeting moderate perioperative blood glucose levels to <180 mg/dL is associated with lower rates of mortality and stroke compared with a liberal target glucose >200 mg/dL, whereas no significant additional benefit was found with more strict glycemic control (<140 mg/dl).

Insulin therapy should be initiated for treatment of persistent hyperglycemia starting at a threshold ≥180 mg/dL

- A basal plus bolus correction insulin regimen, with the addition of nutritional insulin in patients who have good nutritional intake, is the preferred treatment for noncritically ill patients.
- Sole use of sliding scale insulin in the inpatient hospital setting is strongly discouraged.

- If a patient is eating, then rapid-acting insulin SC aligned with meals should be given.
- If a patient is not eating or is getting enteral feeds, rapid-acting insulin SC every 4-6 hours should be given.
- Alternate regimens for 24 hour tube feeding regimens include NPH and rapid-acting insulin 3 times daily or possibly pre-mixed insulin 3 times daily.

- Pre-mixed insulin in the hospital setting otherwise should be generally avoided, due to increased risk of hypoglycemia.

ICU

- IV insulin drip can be very effective.
  However, if the patient is eating, then IV insulin drips can allow marked fluctuations in BG after eating, leading to post-meal hyperglycemia and then significant hypoglycemia, leading to the insulin drip being stopped, which then can cause hyperglycemia.

Peri-operative management

- Perioperative glycemic control tighter than 80–180 mg/dL did not improve outcomes and was associated with more hypoglycemia

- On average a ~25% reduction in the basal insulin dose given the evening before surgery was more likely to achieve perioperative blood glucose levels in the target range with decreased risk for hypoglycemia

DKA

- For significant or severe cases, or if obtunded, IV insulin drip is needed with Regular insulin.

TYPE 1 DM in the ER with DKA

- IV Insulin drip initiation: 0.05-1.0 units/kg/hour with Regular insulin.
- Start as soon as possible in the ER.
- Generally don’t recommend an IV bolus of Regular insulin before the insulin drip.

DKA

- There is no significant difference in outcomes for intravenous regular insulin versus subcutaneous rapid-acting analogs when combined with aggressive fluid management for treating mild or moderate DKA. Patients with uncomplicated DKA may sometimes be treated with subcutaneous insulin in the emergency department or step-down units, an approach that may be safer and more cost-effective than treatment with intravenous insulin.
- Several studies have shown that the use of bicarbonate in patients with DKA made no difference in resolution of acidosis or time to discharge, and its use is generally not recommended.

TRANSITION OFF INSULIN DRIP

- A patient with type 1 DM being transitioned off an insulin drip should probably receive basal insulin, first dose 2-4 hours before stopping the insulin drip (I favor closer to four hours before stopping the drip).
- Alternatively or in addition, rapid-acting insulin can be given about 20-30 minutes before stopping the insulin drip.

TRANSITION OFF INSULIN DRIP

- Basal insulin dose after IV insulin could be calculated as 60-80% of the daily IV insulin dose.
  However, this can vary markedly, especially if patients were on vasopressors or steroids when ill.

GLUCOCORTICOIDS

- Prednisone's peak effect on the BG is about 4-8 hours after an oral dose (but can last up to 10 hours or so).
  Basal insulin might be too long-acting to give appropriately if prednisone is given just once daily. Or at least, rapid-acting insulin might have to be adjusted and the Basal insulin not increased.
- NPH insulin might work well given once daily in the morning if prednisone is used once daily in the AM.

GLUCOCORTICOIDS

- Longer acting glucocorticoids (dexamethasone) or when prednisone/hydrocortisone is given more than once in a day, rapid-acting insulin must be adjusted and basal insulin might be needed.

?Oral agents in the hospital

- Controversial what is best to do.
- At least one study has shown that, in patients with type 2 DM, DPP-4 inhibitor (Januvia, Tradjenta, Onglyza, Nesina) plus basal insulin might be effective.

?Self-managing the DM in the hospital

- Possibly, to some degree in certain patients, such as patients who can carb count and dose their insulin based on this; insulin pump patients; they have to be alert and oriented; they have to be eating generally well and not vomiting.

Bolus tube feeds

- Could give about 1 unit rapid-acting insulin analogue for every 10-15 grams of carbs; given 0-15 minutes before feeds are given.

Transition back to insulin pump from IV insulin drip

- Start the insulin pump about 20-30 minutes before stopping the insulin drip.

DIALYSIS

- HEMODILAYIS: generally insulin doses don’t need to be adjusted when hemodialysis is started.
- Peritoneal Dialysis: insulin types and doses depend on the PD delivery regimen. For instance, PD at nighttime might be best with nighttime NPH insulin and rapid-acting insulin shortly before starting the PD. Continuous PD in the day, etc., can likely use any regimen.

TRANSITION TO HOME

- What was patient on at home and was it working?
- If prior regimen was effective without lows and good A1c control, and if the medicines are not now contra-indicated, probably can resume prior regimen
- If patient needs intensification after hospital, provide outpatient DM education and MNT (Medical Nutrition Therapy)

ORAL MEDS?

- If oral medications are held in the hospital, there should be a protocol for resuming them 1–2 days before discharge, or at discharge.

TRANSITION TO HOME

- Patients often have an emotional attachment to their old regimen (insulin is not just a medication to people with diabetes)
- On admission note, do not record insulin as Humulin or Novolin. Try to record if patient is using a pen or vials and syringes.
- Don’t record insulin as 70/30 (there are different types)
- Diabetes education consult as inpatient often needed, especially on pump patients

TRANSITION TO HOME

- Make sure the medications (oral agents and insulins) and the delivery method (vials with syringes, insulin pens with pen needles) and the glucometer and strips and lancets are prescribed if needed and that the patient’s insurance covers them.

TRANSITION TO HOME

- Many patients are switching back to older insulins at home for cost reasons.

These include Regular (R) insulin and NPH insulin with vials and syringes.

Insulin pen safety needles and mal-delivery of insulin

- In the hospital, pen safety needles are often used to prevent needlestick injuries.
- Don’t give patients insulin pen safety needles (retractable pen needles) to take and use at home. These needles might retract before the plunger is pushed, thereby causing insulin delivery on top of the skin.
- Might suspect mal-delivery of insulin if one BG is markedly higher than the prior BG.

INSULIN PUMPS

- Medtronic Minimed
- Tandem T-Slim, T-Flex
- OmniPOD (tubeless pump)
- Others

PUMPS USE ONLY RAPID-ACTING INSULIN (usually analogues).

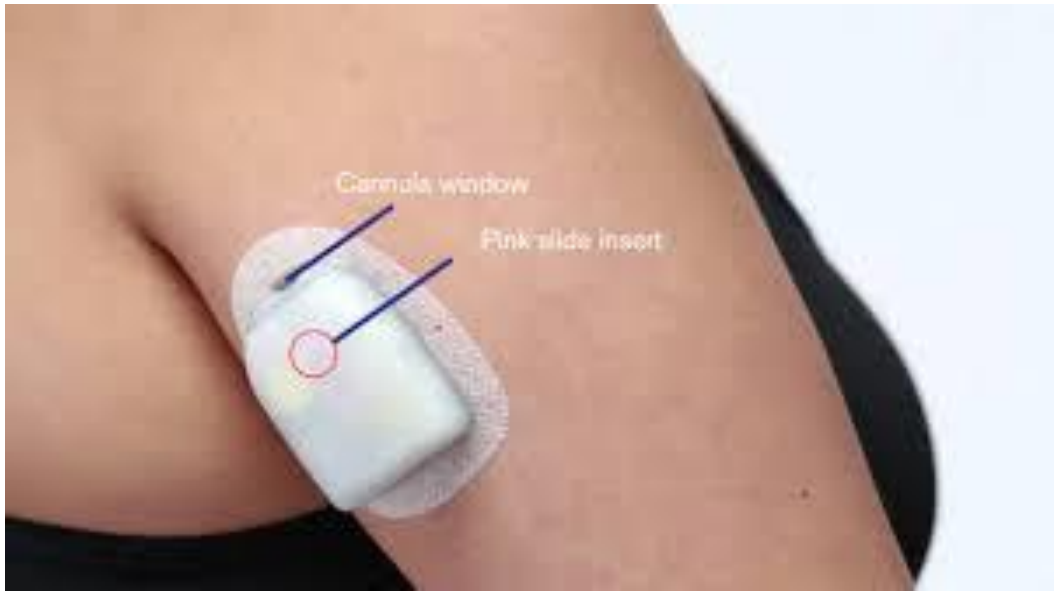
Pumps deliver a basal rate; and bolus (for food and correction dose).

CONTINUOUS GLUCOSE MONITORS (CGM)

- Dexcom G5 and G6 CGM
- Mini-med Guardian CGM
- Freestyle Libre CGM

DEXCOM G6 CGM

OMNIPOD PUMP (tubeless pump)



OMNIPOD PUMP With PDM (Personal Diabetes Manager)

TANDEM INSULIN PUMP

TANDEM INSULIN PUMP and DEXCOM G6 CGM

MEDTRONIC MINIMED PUMP AND GUARDIAN CGM

INSULIN PUMP

- Should not be removed (including infusion site) unless it is thought to be not working or a bad infusion set (most common cause of DKA in pump users) or patient is confused
- Should be left on and operated by patient only if alert and oriented.
- Patient can calculate bolus doses for meals and elevated sugars
- If blood sugar gets low, suspend pump for ½ hour or up to 2 hours or use a temporary basal rate reduction
- Must have protocol in the hospital for the patient to record what insulin doses they gave and need to bolus based on hospital fingerstick BG's.

INSULIN PUMPS

- Causes for blood sugar to be acutely elevated (>400) and potential for DKA:
  - Bad infusion site (even if looks okay). Might be kinked under the skin
  - Bad insulin in pump or vial
  - Pump taken off or turned off for 3 or more hours
  - Malfunctioning pump

Remember, pumps only use rapid-acting insulin analogues

Forgetting a food bolus once might cause high sugar, but generally not DKA

Future directions in hospital

- Insulin pumps in hospital
- Continuous glucose monitoring
- Closed loop pumps (artificial pancreas)
- New insulins
- New meds that don’t cause hypoglycemia

SUPPLEMENTAL SLIDES (will not be covered)

CARBOHYDRATE COUNTING

- Carb ratio:

  500/TDD

TDD (total daily dose): 0.24 x weight in pounds

TDD: 0.05-0.1 units/kg/day

CORRECTION DOSE

- Dose for sliding scale correction is dependent on sensitivity to insulin
- High blood sugar doesn’t mean high dose of insulin for correction
- Sensitivity depends on what type of diabetes, body size, home dose of insulin, etc.

SENSITIVITY

- 1 unit of insulin reduces the blood sugar by how many mg/dl over 1-2 hours?

CALCULATED BY ONE OF THESE FORMULAE:

- 1,500/TDD
- 1,700/TDD
- 1,800/TDD

HIGH SUGAR CORRECTION DOSE

- **(BG-target BG)/sensitivity**

EX: BG=250. Target = 150.

Sensitivity = 50.

(250 mg/dl – 150 mg/dl) = 100

100/50 = 2 extra units of Humalog

BASAL insulin dose

- Starting Lantus dose for those naïve to insulin

10 units or 0.1-0.2 units/kg/day

-Starting dose for those on NPH insulin:

Total NPH dose/2

Eg: if on 70/30 40 units BID, this equals 28 units NPH BID; so Lantus could be started at 28 units once daily.

HOW MUCH RAPID-ACTING INSULIN TO ADD?

- TDD/2 = total expected bolus requirement
- Divide this by 3 and give this before meals

  Note: might have to cut this down initially and if patient not eating predictably

Might need less bolus insulin than expected if on oral agents

THREE THINGS THAT AFFECT BLOOD SUGAR

- RESISTANCE to insulin
- CARBOHYDRATE intake
- HEPATIC glucose production

There are many more factors that affect the BG, of course.