Diabetes Management in the Hospital

Tracy Setji MD MHS
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DukeHealth

Disclosure of Financial Relationships

Tracy Setji MD MHS

None

Objectives

- Review blood glucose goals in the hospital
- Understand optimal therapeutic regimens to reach targets
- Initiating and adjusting insulin therapy
- Recognize common pitfalls in the management of diabetic ketoacidosis
- Discuss insulin solutions for common inpatient challenges (underinsured patients, steroids, enteral feedings)

Case #1

- 56 yo M w/ T2DM, HL, HTN, admitted with CP.
- Evaluating for MI. Considering cardiac cath during hospitalization but currently has diet ordered.
- Home DM meds: metformin 1000 mg BID, glimepiride 4 mg daily, liraglutide 1.8 mg daily
- 100 kg, VS normal, PE unremarkable
- A1c 7.8% 5 months ago, GFR >60
- How do you manage his DM?

American Diabetes Association Recommendations

- Upon admission, check A1c on all pts w/ DM or hyperglycemia if they have not had one drawn in the past 3 months
- This patient's A1c is due to be checked
- What should our BG targets be in the hospital and when should we monitor?

Diabetes Care 2017;40:S120-S127

BG Monitoring

- Needs to correlate w/ insulin administration (thus usually before meals, at bedtime
- Can check overnight BG if concern for hypoglycemia overnight or if labile BGs in the mornings
- If NPO and on insulin, monitor BG q 4-6 hours

Diabetes Care 2009;32:1119

BG Targets: NICE-SUGAR in ICU

- Normoglycemia in Intensive Care Evaluation – Survival Using Glucose Algorithm Regulation
- Hypoglycemia in tightly controlled groups (81-108) resulted in increased mortality vs. moderately controlled cohorts (≤180)
  - 90-day Mortality 27.5% (829/3010) vs. 24.9% (751/3012)
  - Absolute difference 2.6% (95% CI, 0.4-0.8), Odd ratio for death in intensive control 1.14 (95% CI, 1.02-1.28))
- Thus shifted away from tight control in the ICU

Diabetes Care 2017;40:S120-S127, NEJM 2009;360:1283

American Diabetes Association Recommendations – Inpatient Targets

- Insulin therapy should be used if BGs persistently ≥180 mg/dl. Once started…
- **Goal 140-180 mg/dl for majority of critically ill and noncritically ill patients**
- More stringent goals (i.e. <140 mg/dl) may be used in some patients (cardiac surgery, neurologic events, acute cardiac ischemia)
- Higher goals acceptable in some patients also (severe comorbidities, terminally ill)

Diabetes Care 2017;40:S120-S127
Ann Intern Med 2016;19:164

We know our BG goals, but what is the optimal way to reach these targets?

- Insulin is generally preferred to control glucose in the hospital
- Insulin pens are not recommended due to potential blood-borne diseases (i.e. pens are for single patient use only
- Can consider resuming oral medications 1-2 days before discharge

Diabetes Care 2017;40:S120-S127

Limitations of Outpatient Therapies for Hyperglycemia in the Hospital

- Sulfonylureas - Hypoglycemia, especially if variable PO intake
- Metformin - Lactic acidosis- accumulation if rising creatinine
- Thiazolidinediones - Fluid retention, caution in CHF, delay in onset 4-6 weeks
- SGLT2 inhibitors - osmotic diuresis, increase risk of mycotic GU infections, reports of DKA
- DPP-4 - glucose lowering is modest and renal adjustment is needed w/ some DPP-4 inhibitors.
  - Effectiveness is fair but recent promising new inpatient literature…

Diabetes Care 2017;40:S120-S127

Sitagliptin: Promising new study

- Multicenter, prospective, open-label, non-inferiority RCT
- 138 sitagliptin-basal vs. 139 basal-bolus
- Mean BG similar
  - 176 mg/dl +/-50 vs. 174 mg/dl +/-50
  - difference 1.9 mg/dl (95% CI -11 to 13)
- LOS, treatment failure, hospital complications similar
- Hypoglycemia similar
  - 9% sitagliptin-basal vs. 12% basal-bolus, p=0.45

Lancet Diabetes Endocrinol. 2017;5(2):125

Sitagliptin: Promising new study

- Sitagliptin-basal may be option for some pts, particularly those that have mild elevation in A1c
- Increased treatment failure seen as A1c increases
- May not be generalizable and further studies would be beneficial
- CHF association: saxagliptin, alogliptin

Lancet Diabetes Endocrinol. 2017;5(2):125

Initial Total Daily Dose Estimations (Converting from OHAs or new insulin start)

- Total Daily Dose (TDD) → 50% basal, 50% prandial
- 0.3 units/kg/day (thus basal 0.15 units/kg/day)
  - Type 1 diabetes
    - Insulin naïve
    - Low insulin resistance (thin, diet controlled)
    - Impaired renal function (may need even less)
- 0.5 units/kg/day (thus basal 0.25 units/kg/day)
  - Type 2 diabetes
    - May need more: Higher insulin resistance (high stress, steroids, obese) or if long-standing, poorly controlled DM

Basal – Bolus (Prandial) Insulin

- Basal insulin – the amount of insulin necessary to regulate blood glucose when completely NPO
  - Lantus (U100 glargine); Basaglar (U100 glargine); Toujeo (U300 glargine)
  - Levemir (U100 detemir)
  - Tresiba (U100, U200 degludec)
- Bolus insulin – the amount of insulin needed before a meal to regulate blood glucose rise after eating
  - Novolog (U100 aspart)
  - Humalog (U100, U200 lispro)
  - Apidra (U100 glulisine)

U100 = 100 units/ml; U200 = 200 units/ml; U300 = 300 units/ml

Insulin Therapy Options – Noncritically Ill Patients

- If good PO intake → basal, nutritional, and correction is preferred
- If poor PO intake or NPO → basal +/- correction insulin
- If eating but PO intake variable, can dose rapid-acting immediately after the pt eats
- Caution with use of correction insulin if the pt has renal dysfunction (increased risk of stacking) and/or the timing of BG monitoring and insulin administration in the hospital is poor
- Increased hypoglycemia (inpt) with premixed insulin

Diabetes Care 2017;40:S120-S127; Diabetes Care 2011; 34:256; Endocr Pract 2015;21:807; Endocrine 2016;51:417

Back to Case #1

- 56 yo M w/ T2DM, HL, HTN, admitted with CP.
- Evaluating for MI. Considering cardiac cath during hospitalization but currently has diet ordered.
- Home DM meds: metformin 1000 mg BID, glimepiride 4 mg daily, liraglutide 1.8 mg daily
- 100 kg, VS normal, PE unremarkable
- A1c 7.8% 5 months ago, GFR >60
- How do you manage his DM?

Insulin - Dose based on weight

- Type 2 DM, requires 3 oral agents as an outpatient w/ previously suboptimal control
- A1c ordered and pending
- BG currently 232, GFR normal
- 0.4-0.5 units/kg/day (wt = 100 kg)
  - 40-50 units TDD
  - 20-25 units basal daily
  - 6-8 units each meal if anticipate good PO intake
    - *I would not schedule correction insulin until response to above has been monitored

Scenario #1 -- BGs the next day: What would you do?

	Breakfast	Lunch	Supper	Bedtime
BG	N/A	240	270	222
Insulin	In ED, BG 232	8 units RA	8 units RA; 16:00 25 units basal given early	
Correction			4 units	
--	--	--	--	--
BG	229	219		
Insulin	8 units RA	8 units		
Correction	2 units	2 units		

Increase insulin doses by about 20%.

Increase Basal to 30 units daily; increase prandial to 10 units w/ meals.

RA = Rapid acting

What % should you use to calculate reductions or increases in insulin doses?

- 10% if slightly off target
  - BGs running “tight” (ie. 85 to l00) but not overtly low, OR BGs running a little higher than 180
- 20% if BGs a little more off target
  - BGs running 70-100 and/or mild hypoglycemia, OR BGs in 200s
- 30% or more if BGs significantly off target
  - Moderate to severe hypoglycemia, OR BG in 300s or more
- Sometimes need greater % changes
- Look at the trends and target the problematic insulin doses

Scenario #2 – Same patient but different BG response: What do you do?

	Breakfast	Lunch	Supper	Bedtime
BG	N/A	240	230	198
Insulin	In ED, BG 232	8 units RA	8 units RA; 16:00 25 units basal given early	
Correction			2 units	
--	--	--	--	--
BG	98	148		
Insulin	8 units RA	8 units		
Correction				

Note 100 pt drop between bedtime and next morning.

This large of a drop suggests too much basal on board.

Reduce dose by 10-20% → Decrease basal to 20-22 units at HS

RA = Rapid acting

Scenario #2 -- BGs the next day: What if you had not adjusted…..

E	Breakfast	Lunch	Supper	Bedtime
BG	N/A	240	230	198
Insulin	In ED, BG 232	8 units RA	8 units RA; 16:00 25 units basal given early	
Correction			2 units	
--	--	--	--	--
BG	98	148	132	147
Insulin	8 units RA	8 units	8 units	25 units basal
--	--	--	--	--
BG	52 ☹	289		
Insulin	Held			
Correction				

Hypoglycemia may peak in the hospital b/w MN and 6am in pts on basal insulin

RA = Rapid acting; Endocr Pract 2015;21:501

Hypoglycemia

- Hypoglycemia Definition:
  - Previously defined in the hospital as <70 mg/dl; severe if <40 mg/dl
  - 2017: Clinically significant if BG <54 mg/dl
    - Severe if associated with severe cognitive impairment regardless of the BG level
    - ≤70 mg/dl alert value

Diabetes Care 2017;40:S120-S127

Hypoglycemia

- Hypoglycemia predicts hypoglycemia
- 84% of patients with BG <40 mg/dl had prior BG <70 mg/dl in the same admission

- Treatment: 15/15 rule
  - Treat with 15 g CHO and recheck BG in 15 minutes
  - Hospital should have hypoglycemia treatment protocol

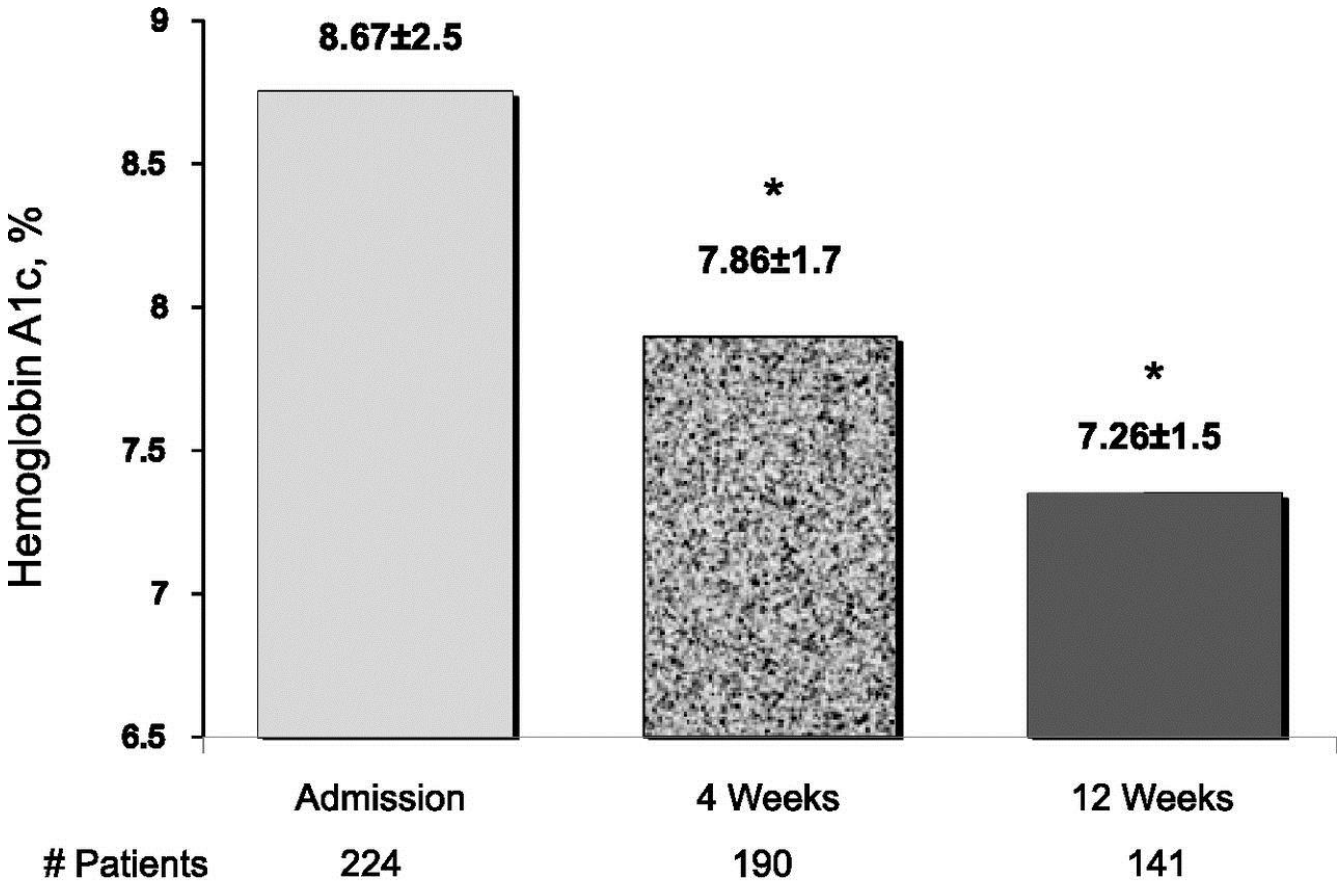
Endocr Pract 2014;20:1051

Case #1 Going home: How do you decide what to medications to prescribe upon discharge?

- Multicenter, prospective, open-label study evaluating discharge algorithm based on A1c, 224 patients
- If A1c <7%, discharged on preadmission DM therapy
- If A1c b/w 7-9%, discharged on preadmission regimen plus 50% of hospital dose of glargine
- If A1c >9%, discharged on oral agents plus glargine OR basal bolus regimen at 80% of the inpatient dose
- Primary outcome change in A1c at 12 wks

Diabetes Care 2014;37(11):2934-9

Change in HbA1c concentration at 4 weeks and 12 weeks after hospital discharge



Data are mean ±SD

* p<0.001 from admission

Guillermo E. Umpierrez et al. Dia Care 2014;37:2934-2939

American Diabetes Association.

A1c improved, but they did have more hypoglycemia

- Percentage of patients who reported hypoglycemia after discharge
  - 22% of pts in oral agents only group
  - 30% in oral agents+basal insulin
  - 44% in basal-bolus group
  - 25% in basal only
  - P=0.039
- Good algorithm, but would consider a more conservative lower limit of A1c
  - 7.5 or 8, especially in patients with comorbidites or advanced age

Diabetes Care 2014;37(11):2934-9

Case #2

- 24 yo F w/ T1DM admitted with DKA
- Reports viral illness resulted in N/V/D
- She did not take insulin b/c she was not eating and her BG was only 132 last night
- Now BG 352, AG20, bicarb 10, K 2.9
- Started on IVF in the ED
- What do you need to give prior to starting insulin infusion?
- Replete K – Don’t start IV insulin until K $\geq$3.3
- Add dextrose to IVF once BG <200-250

Transition from IV to SC Insulin

- IV insulin has a short half-life and should not be discontinued until subcutaneous (SC) medication has been initiated
- Patients should receive SC basal insulin 1-2 hrs prior to discontinuing IV insulin.
  - *I usually wait ≥2 hours after glargine/levemir dose

Diabetes Care 2017;40:S120-127

Converting from IV to SC

- Look at infusion rates AND weight based dosing
  - If infusion rates are stable and BG well controlled, overnight/NPO infusion rates are a good estimation of basal needs
    - Example: pt requires 1 unit/hr from MN-6am, probably going to need 20-24 units basal per day.
      - *I usually multiply ave hourly basal rate overnight by 20 to get basal (glargine/levemir) dose
    - If eating, will need about the same amount of insulin for **total** bolus insulin (ie. 6-8 units w/ each meal for total of 18-24 units bolus insulin/day)

Converting from IV to SC

- Most important: follow up soon after transition so that you can see if you need to adjust doses
  - Don’t wait until the next day to see what happened b/c you may over or under estimate needs
- Caution with renal failure, elderly, Type 1, and hypoglycemic unawareness

Common Challenges in the Hospital

Underinsured patients: What if you want to use Regular-NPH regimens?

- Basal-bolus is generally preferred in the hospital, but may want to titrate outpatient insulin therapies
- Regular and NPH for pts without insurance and/or cannot afford basal-bolus
  - Divide TDD of insulin by 4 for regimen of Regular TIDAC and NPH HS
    - Example if you want to use a TDD of 60 units:
      - 60/4 = 15 → 15R tidac, 15 Nhs

What about 70/30 regimens?

- Pt (and you) are concerned about feasibility of doing more than 2 shots per day as well as cost
- Thus you are considering 70/30 before breakfast and dinner
- Example if you want to use TDD of 60 units and transition to 70/30 upon discharge:
  - 36 units before breakfast, 24 before dinner
    - 60% am (50-66%) and 40% in pm (33-50%)
    - Need to take into account any long acting insulin that pt may have on board during transition

Pt is being started on Enteral/Parenteral Feedings

- Optimize BG before enteral/parenteral feeding starts
- Frequent monitoring of BG is required after initiation of enteral feeding
- Limited literature to guide therapy

ADA Recommendations

- Continuous enteral feedings
  - Basal insulin:
    - Continue prior basal if known and effective
    - Calculate from TDD (30-50%)
      - *personal experience is that basal is closer to 30-35% when pt is on enteral feeds
    - NPH/detemir 5 units BID or glargine 10 units daily
  - Nutritional and correction insulin:
    - Regular insulin q 6hr OR rapid acting SC insulin q 4 hr
    - Starting 1 unit per 10-15 g CHO
    - Monitor and adjust daily

Diabetes Care 2017;40:S120-S127

ADA Recommendations

- Bolus enteral feedings
  - Basal insulin:
    - Continue prior basal if known and effective
    - Calculate from TDD (30-50%)
      - *personal experience: basal closer to 30-35% when pt is on enteral feeds
    - NPH/detemir 5 units BID or glargine 10 units daily
  - Nutritional and correction insulin:
    - Regular insulin OR rapid acting SC insulin before each feeding
      - *personal experience: if bolus feeds are q 3 hrs, would give either rapid acting before each feeding (q 3 hr) or regular before every other feeding (q 6hr) to avoid stacking with regular insulin
    - Starting 1 unit per 10-15 g CHO; follow and adjust daily

Diabetes Care 2017;40:S120-S127

ADA Recommendations

- Parenteral feedings
  - Add regular insulin to TPN IV solution, starting with 1 unit per 10 g CHO, particularly if pt required >20 units of correctional insulin in 24 hours
  - Monitor and adjust daily
  - Use correction Regular insulin q 6 hr OR rapid acting insulin q 4 hr for hyperglycemia
  - If type 1, always need basal SC insulin also

Diabetes Care 2017;40:S120-S127

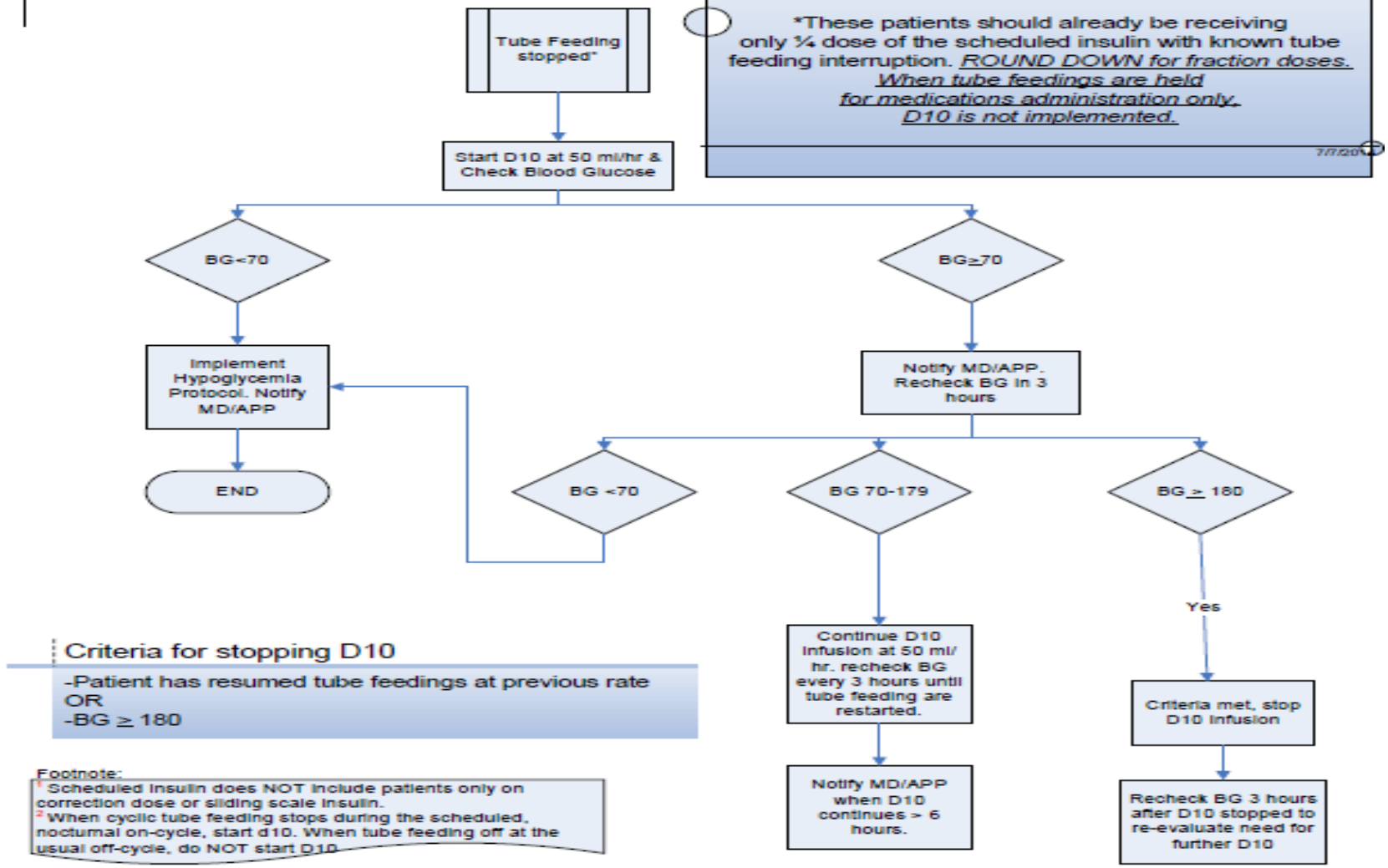
Risk of hypoglycemia if enteral feeding is interrupted for any reason

- Consider a protocol for starting IVF w/ dextrose in patients on scheduled SC insulin that is covering enteral feedings
- Protocol should be implemented if enteral feeds are stopped/interrupted for any reason
- This will help prevent patient from becoming hypoglycemic due to the insulin that is already on board

July 2014

D10 Algorithm for Interrupted Tube Feedings

IF the patient is on scheduled[1] SQ insulin
AND TUBE FEEDINGS (continuous/bolus/cyclic[2]) are stopped
for *ANY* Planned or Unplanned Reason-
THEN, start D10.



*These patients should already be receiving only ¼ dose of the scheduled insulin with known tube feeding interruption. *ROUND DOWN for fraction doses.*
When tube feedings are held for medications administration only, D10 is not implemented.

7/7/20

Criteria for stopping D10

-Patient has resumed tube feedings at previous rate
OR
-BG ≥ 180

Footnote:
[1] Scheduled insulin does NOT include patients only on correction dose or sliding scale insulin.
[2] When cyclic tube feeding stops during the scheduled, nocturnal on-cycle, start d10. When tube feeding off at the usual off-cycle, do NOT start D10

High dose steroids –what should you do with insulin regimen?

- Depends on the steroid…
- Dexamethasone or steroids dosed >1 time/day may need increases in all insulin doses
  - *Often need 20-30% increase in doses
- Prednisone given in the morning
  - Peak effect 4-8 hrs later; most of effect is out of system by HS
  - Need more insulin during the day but NOT necessarily more basal overnight!
    - *If not normally on insulin, NPH 0.1-0.3 unit/kg/day administered when prednisone is given can be very effective

CASES

- 57 yo Male admitted for CP
- DM2 x 12 yrs, A1c 7.7% on metformin 1000 mg BID, pioglitazone 15 mg daily, and glargine 25 units SQ QHS
- Wt 80 kg, cr 1.1, glucose 268, other labs nl
- How should we treat DM?
  - Insulin 0.5 unit/kg TDD
  - 20 basal QHS (25 would probably be fine if desired), 7 log w/ meals
  - Upon d/c, resume home regimen

CASES

- 47 yo Female admitted pneumonia
- No h/o DM but BG 241 on chem 7.
- A1c checked and is 8.4%, cr normal.
- Wt 60 kg
- How do you treat in hospital? Upon discharge?
  - Insulin in hospital (0.3 unit/kg TDD; 9 basal QHS, 3 log w/ meals)
  - Metformin only upon d/c

CASES

- 36 yo M admitted for pyelo / nephrolithiasis
- History of poorly controlled T2DM for about 8 yrs. Currently on lantus 90 units daily and lispro 60 units w/ meals but *cannot afford it*
- A1c 14, Wt 80 kg, cr 1.2, BG 400
- Treatment?
  - Wt based dose 0.5-0.7 unit/kg (thus TDD 40-56 units)
  - 25 basal QHS; 8 log w/ meals; Alternative in preparation for discharge on affordable insulin 12 units Reg TIDAC, 12 units NPH QHS

CASES

- 84 yo F admitted after falling at home
- H/o dementia, but still has some ability to communicate w/ family
- BG noted to be 212 upon admission, subsequent BG 172; A1c checked and it is 7.2%.
- Do you need to do anything?
- Should you start correction dose insulin in the hospital?

Thank you for your participation!

- Questions?

- tracy.setji@duke.edu