Diabetes Management in the Hospital

Tracy Setji MD MHS
July 2017
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?
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 $\geq 180$ 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
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
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
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)

\[ U100 = 100 \text{ units/ml}; U200 = 200 \text{ units/ml}; U300 = 300 \text{ units/ml} \]
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?

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

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 100) 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?

<table>
<thead>
<tr>
<th></th>
<th>Breakfast</th>
<th>Lunch</th>
<th>Supper</th>
<th>Bedtime</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BG</strong></td>
<td>N/A</td>
<td>240</td>
<td>230</td>
<td>198</td>
</tr>
<tr>
<td><strong>Insulin</strong></td>
<td>In ED, BG 232</td>
<td>8 units RA</td>
<td>8 units RA; 16:00 25 units basal given early</td>
<td></td>
</tr>
<tr>
<td><strong>Correction</strong></td>
<td></td>
<td></td>
<td>2 units</td>
<td></td>
</tr>
<tr>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td><strong>BG</strong></td>
<td>98</td>
<td>148</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Insulin</strong></td>
<td>8 units RA</td>
<td>8 units</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Correction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.....

<table>
<thead>
<tr>
<th>E</th>
<th>Breakfast</th>
<th>Lunch</th>
<th>Supper</th>
<th>Bedtime</th>
</tr>
</thead>
<tbody>
<tr>
<td>BG</td>
<td>N/A</td>
<td>240</td>
<td>230</td>
<td>198</td>
</tr>
<tr>
<td>Insulin</td>
<td>In ED, BG 232</td>
<td>8 units RA</td>
<td>8 units RA; 16:00 25 units basal given early</td>
<td></td>
</tr>
<tr>
<td>Correction</td>
<td></td>
<td></td>
<td>2 units</td>
<td></td>
</tr>
<tr>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>BG</td>
<td>98</td>
<td>148</td>
<td>132</td>
<td>147</td>
</tr>
<tr>
<td>Insulin</td>
<td>8 units RA</td>
<td>8 units</td>
<td>8 units</td>
<td>25 units basal</td>
</tr>
<tr>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>BG</td>
<td>52 😞</td>
<td>289</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulin</td>
<td>Held</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*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
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

![Graph showing change in HbA1c concentration](image)

- **Admission**: 8.67±2.5
- **4 Weeks**: 7.86±1.7
- **12 Weeks**: 7.26±1.5

# Patients
- Admission: 224
- 4 Weeks: 190
- 12 Weeks: 141

Data are mean ±SD

* p<0.001 from admission

Guillermo E. Umpierrez et al. Dia Care 2014;37:2934-2939
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 comorbidities 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 ≥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/le vemir dose
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:
      – $60/4 = 15 \rightarrow 15$R 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
D10 Algorithm for Interrupted Tube Feedings

**IF** the patient is on scheduled¹ SQ insulin AND TUBE FEEDINGS (continuous/bolus/cyclic²) are stopped for ANY Planned or Unplanned Reason-

**THEN**, start D10.

---

1. *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.*

---

**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