“A Touch of Sugar”: Controlling Hyperglycemia in Acute Care Settings

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Disclosure

- I do not have a vested interest in or affiliation with any corporate organization offering financial support or grant monies for this continuing education activity, or any affiliation with an organization whose philosophy could potentially bias my presentation.

Disclosure

- I do have a vested interest in or affiliation with the following companies or organizations
  - Speaker’s Board
    - Novo Nordisk
    - Sanofi

Disclosure

- As in any situation, clinical judgment supersedes these recommendations and each patient’s therapeutic needs must be assessed on a case-by-case basis.

Objectives

- Upon completion of this activity, the participant should be able to:
  - Apply evidence based practice to diabetic patients across transitions of care including from home to hospital and hospital to discharge.
  - Initiate appropriate therapy in the hospitalized hyperglycemic patient.
  - Discuss optimal diabetic management when transitioning between critical care and step down care.
  - Describe issues surrounding orders to resume home insulin pumps.

Course Outline

- Introduction: Basal:Bolus regimens
- General floor treatment recommendations
  - Patient case
- Critical care treatment guidelines
  - 2013 SCCM Insulin Infusion Guidelines
  - Conversion from IV to Subcutaneous insulin
  - Patient case
- Clinical scenarios
  - Steroid induced hyperglycemia
  - Insulin pumps
Sliding Scale Insulin

- ADA: "Prolonged therapy with sliding scale insulin (SSI) as the sole regimen is ineffective in the majority of patients, increases risk of both hypoglycemia and hyperglycemia..."

Evidence Base

- Relative lack of data/guidelines for inpatients
  - Most data in critical care – IV Infusion
  - General population overlooked, except
    - RABBIT trials
  - Recommendations based on clinical experience expert consensus

Basal-Bolus Regimens: Plan ahead!

- Goal is to change the way we think about glycemic control
  - Think prospectively!

Key References

- Society of Hospital Medicine: Quality Improvement Resource Room. Improving Glycemic Control, Preventing Hypoglycemia, and Optimizing Care of the Inpatient with Hyperglycemia and Diabetes.

Basal-Bolus-Correction Theory

- Goal
  - Mimic natural physiology of insulin release

- How?
  - Mix & match different insulin formulations
  - Maximize PK differences to achieve goal

Glossary

- Basal insulin
  - Mimics fasting insulin release in non-DM patient. Long acting analogs recommended

- Bolus insulin
  - Mimics insulin release in response to nutrition (aka: nutritional or prandial insulin)

- Correction scale
  - Accounts for under-dosing of insulin or increased nutritional intake.
  - Used in conjunction with scheduled administrations of insulin.
  - Analogous to sliding scale insulin
The Physiological Insulin Profile

Adapted from Polonsky, et al. 1988.

Basal/Bolus Treatment Program

Plasma Insulin

SAA: Short Acting Analog
LAA: Long Acting Analog

Blood Glucose Targets

- Critical Care
  - Less than 180 mg/dL
  - Greater than 70 mg/dL
    - Greater than 100 mg/dL in neuro cases
  - Optimal BG range undefined

- Non-critically ill
  - Pre-meal: less than 140 mg/dL
  - Random: less than 180 mg/dL
    - Reassess treatment for BG less than 100 mg/dL
    - Modify for BG less than 70 mg/dL

Patient Case: MS


- PMH:
  - T2DM x 7 years
  - Hyperlipidemia
  - Osteoarthritis
  - Obesity

Patient case: MS

- Patient data
  - 68 yo female, Wt: 108 kg
  - A1c 2 months ago: 9.1%

- Home meds:
  - APAP 650 mg po four times daily
  - Aspirin EC 81 mg po qDay
  - Atorvastatin 20 mg po qDay
  - Metformin 1000 mg po BID
  - Sitagliptin 50 mg po BID
  - Glyburide 5 mg po BID
Patient case: MS

- BG data:
  - Admission 2300: 273 mg/dL
  - Day #1 0500: 227 mg/dL
  - Day #1 0900: 287 mg/dL

- Inpatient Medications
  - APAP 650 mg po four times daily
  - Aspirin EC 81 mg po qDay
  - Atorvastatin 20 mg po qDay
  - Ceftriaxone 2 gm IV q24h
  - Azithromycin 500 mg IV q24h

How will we manage MS’s hyperglycemia?

Initial Treatment Plans

- Discontinue oral agents
  - Many contraindications for inpatients
  - Not specifically studied for inpatients
  - May cloud the picture of control

Weight Based Dosing

1. Calculate initial estimated Total Daily Dose of Insulin (TDDI) based on patient factors

2. Divide the TDDI into a 50:50 ratio between Basal:Bolus insulin
   1. Give basal once daily (at bedtime)
   2. Split bolus according to intake status
      - Choose bolus insulin to max PK advantage

3. Select a Correction Scale based on estimated TDDI

Step 1: Estimating TDDI

- Type 1
  - Use therapy as at home
    - MUST have basal insulin (or constant IV infusion) to prevent ketosis
    - May hold or cut mealtime doses if intake is poor
    - If on pump, calculate 24hr basal requirement
      - Discontinue pump
      - Order basal requirement as long acting analog. Start now
    - If therapy unknown,
      - Basal: 0.2 – 0.3 units/kg/day
      - Bolus: 0.05 - 0.1 units/kg/dose
      - Correction Scale

References:
Step 1: Estimating TDDI

- Type 2
  - Conservative starting point for most:
    - 0.4 to 0.5 units/kg/day
  - High risk for hypoglycemia (very lean, significant renal/hepatic failure, hemodialysis):
    - 0.3 units/kg/day
  - Overweight/known insulin resistance/high dose steroid tx
    - 0.6 – 1 units/kg/day
- Split TDDI into a 50:50 ratio of basal:bolus insulin
- Consider 30:70 ratio for steroid induced hyperglycemia


Step 2: Ordering Insulin-Basal

- Basal insulin (Long acting insulin)
  - 50% of TDDI calculation
    - Long acting analogs (Detemir/Glargine)
      - Preferred by ADA/AACE
      - Usually dosed at bedtime
    - NPH
      - Requires q12hr dosing
      - Higher risk of hypoglycemia
      - Less expensive
  - Adjust dose based on AM FBG
    - If using BID dosing adjust AM dose on pre-dinner BG
    - Adjust by 10 to 20% based on degree of poor control

Step 2: Ordering Insulin

- Bolus Insulin
  - For regular diet:
    - Use 50% of TDDI split w/meals (or 0.05 to 0.1 units/kg/meal)
    - Use short acting analogs– most physiologic
  - For continuous supplemental feeds (TF/TPN)
    - Use 50% of TDDI split q6h (or 0.05 to 0.1 units/kg/dose)
    - Use regular insulin – PK properties
  - For NPO
    - No bolus insulin necessary
    - Continue basal orders

Step 2: Ordering Insulin

- Adjustment of Bolus doses
  - Adjust by 1-2 units per dose for:
    - Pre-meal BG greater than 140 mg/dl
    - Degree and uniformity determines adjustment
      - May need larger adjustments, use correction scale to guide
    - Work backwards
      - i.e. Lunch BG indicative of Breakfast insulin dose, etc.
Step 3: Correction Scale

- NOT sliding scale – being combined with Basal (& Bolus)
  - Accounts for underestimation of TDDI, intake, and insulin resistance
- Select scale based off TDDI calculation
  - Pre-set scales available

Step 3: Correction Insulin

- Algorithm based on TDDI - example
  Medium-Dose Analog Insulin Algorithm (requires 40 to 80 units per day)

<table>
<thead>
<tr>
<th>Premeal BG</th>
<th>Extra Insulin AC</th>
<th>Extra Insulin HS</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 – 199</td>
<td>1 unit</td>
<td>0 unit</td>
</tr>
<tr>
<td>200 – 249</td>
<td>3 units</td>
<td>2 unit</td>
</tr>
<tr>
<td>250 – 299</td>
<td>5 units</td>
<td>3 units</td>
</tr>
<tr>
<td>300 – 349</td>
<td>7 units</td>
<td>4 units</td>
</tr>
<tr>
<td>350 or greater</td>
<td>9 units</td>
<td>5 unit</td>
</tr>
</tbody>
</table>

Preventing Hypoglycemia

- Orders and protocols for treatment of low levels
  - Attach to every patient receiving insulin
- Utilizing HOLD orders
  - Not expected to eat or TF/TPN stopped
- Managing orders to account for decreased insulin need
  - Decreasing steroid doses
  - Resolving stress-related hyperglycemia

Patient case: MS

- Patient data
  - 68 yo female, Wt: 108 kg
  - A1c 2 months ago: 9.1%
  - SrCr: 1.1 (mild elevation)
  - Ate breakfast. Good appetite since antibiotics/fluid given.

RABBIT 2: Glycemic Control With Basal-Bolus vs Sliding-Scale Insulin


N=130 insulin-naïve hospitalized nonsurgical patients with T2DM
n=9 with BG >240 mg/dL

Blood glucose (mg/dL)

Days of therapy

Admit 1 2 3 4 5 6 7
100 120 140 160 180 200 220 240
Sliding-scale switching therapy
Admit 1 2 3 4 5 6 7
Basal-bolus

**P <.01; †P <.05; ‡Long-acting insulin (glargine) once daily + short-acting insulin (glulisine) before meals, total dose 0.4 unit/kg (BG 140-200 mg/dL) or 0.5 unit/kg (BG 201-400 mg/dL).**

Patient case: MS

- Step 1: Discontinue oral agents
- Step 2: Calculate TDDI
  - TDDI = 0.5 units/kg/day * 108 kg = 54 units/day
- Step 3: Split into 50:50 ratio
  - Basal insulin (detemir/glargine): 27 units at bedtime
    • Consider giving partial dose now
  - Nutritional insulin (aspart/lispro/glulisine): 9 units w/ meals
  - Medium dose correction scale
- Step 4: Daily follow-up
  - Adjust based on BG data

- Step 5: Discharge planning – Start early
  - A1c 9.1% despite 3 oral meds...
    • Opportunity to talk to patient about starting insulin as outpatient – it is indicated per guidelines
    • Allow patient to self-administer under direct supervision (if allowed per policy) to address potential fears
    • Assess diabetic education level and address knowledge gaps - ? CDE consult
    • Communicate with PCP about starting basal insulin therapy
  - Start “home regimen” 1 to 2 days prior to discharge if possible and monitor.

Patient Case - AM

- Patient data
  - 63 yo male, Wt: 120 kg
  - A1c 1 month ago: 8.2%
- Home meds:
  - Aspirin EC 81 mg po qDay
  - Metoprolol 50 mg po BID
  - Lisinopril 5 mg po qDay
  - Atorvastatin 20 mg po qDay
  - Metformin 500 mg po BID
  - Glyburide 5 mg po BID

ICU Patient Case - AM

- HPI: 63 yo male. Septic shock, secondary to bowel perforation.
  - S/P washout and repair. Admitted to ICU post-op.
  - Adequate IVF resuscitation w/ NS. Currently on norepinephrine at 8 mcg/min, Goal MAP 65, At goal MAP, currently weaning. NPO.
- PMH:
  - CAD
  - HTN
  - T2DM

- Labs:
  - Na, K, Cl, Mag, Ca CO2 all WNL. On replacement protocols for K, Mag.
  - SrCr 2.4, BUN 32 (baseline SrCr 1 mg/dL)
  - Blood Glucose over past 12 hours with CMP q6h:
    - 0100: 220 mg/dL
    - 0700: 325 mg/dL

- Problems:
  1. Sepsis
  2. Hypotension
  3. Acute Kidney Injury
  4. Hyperglycemia

Critical Care Guidelines
How should we manage AM’s hyperglycemia?

SCCM 2012 Hyperglycemia Guidelines:
Key Points (i)
1. Hyperglycemia is associated with poor patient outcomes (mortality)
2. Use insulin infusion therapies in ICU to target:
   a) BGs less than 150 mg/dL (absolutely less than 180)
   b) Low rate of hyperglycemia
      a) Defined as BG less than 70 mg/dL,
      b) In neuro cases, less than 100 mg/dL
3. Automatic triggers for protocol initiation
   a) i.e. Initiate protocol if BG values over 150 mg/dL twice in 12 hours


SCCM 2012 Hyperglycemia Guidelines:
Key Points (ii)
4. Monitor BG every 1 to 2 hours
5. Consider whole blood sampling (not finger sticks) for some patients:
   a) Shock
   b) Vasopressor tx
   c) Severe peripheral edema
6. Use 1 unit/mL concentration using regular insulin
   a) i.e. Regular insulin 100 units in 100 mL NS
   b) Prime tubing with 20 mL of infusion solution

IIP Selection Considerations
- Achieve glycemic control in a short timeframe
- Minimal hypoglycemia
- Low operator error rate
- Minimal nursing time required
- Applicable to wide array of patient populations
  - 1 IIP across different ICUs (think of float nurses!)
  - 1 Standard DKA protocol

- Consider a protocol with a “multiplier” scheme opposed to a “fixed dose” scheme
  - Accounts for rate of change and current infusion rate
- Consider computer-guided algorithms - $$$
  - Glucommander
  - EndoTool

SCCM 2012 Hyperglycemia Guidelines:
Key Points (iii)
7. Use subcutaneous insulin sparingly in critically ill
   a) Rapidly changing clinical status
      a) Nutrition
      b) Elimination
   b) Poor perfusion to subcutaneous tissue
8. Develop glucometrics to monitor protocol
   a) Mean/Median BG levels
   b) Time in goal range (% of readings)
   c) Hypoglycemic events (suggest any severe hypoglycemia has RCA done)
   d) Error reporting

SCCM 2012 Hyperglycemia Guidelines:
Key Points (iv)
9. Once stable, transition to subcutaneous Basal-Bolus regimen
   a) No planned interruption of nutrition
   b) Edema resolved
   c) Off Vasopressors
   d) BG in range on a stable infusion rate
10. Calculate Basal-Bolus dose based off of the infusion rate

IV to Subcutaneous Transition

When?
- Indications for IV insulin must be resolved
- Rate should be stable (4 to 6 hours)
- BG should be in goal range

Who?
- All T1DM must be converted to a regimen which includes basal insulin
- T2DM on a rate less than 0.5 mL/hr
  • May not need to be converted


IV to Subcutaneous Transition

Dose Calculation
• How?
  1. Calculate Total Daily Dose (TDD) of insulin based on mean infusion rate
    • Use safety factor of 60 to 80% of 24hr requirement
      - TDD = (Mean rate * 24 hours * 0.6 or 0.8)

IV to Subcutaneous Transition

Basal Dosing
2. If patient is fasting (no substantial nutrition i.e. less than 120 gm of IV dextrose):
   - TDD = Basal dose
   - Use Long acting analog

3. If patient getting nutrition:
   - Basal dose = 50% of TDD calculation
   - Use long acting analog

IV to Subcutaneous Transition

Nutritional Dosing
2. If feeding to be started:
   - Use 10 to 20% of basal dose as nutritional dose w/ each meal or q6h (If on tube feed/TPN)
   - Hold orders
     • If not expected to eat/enteral feed not tolerated/TPN dc’d
     • BG less than 80
     - Use short acting analog for meals
     - Use regular insulin for supplemental feed

3. If being fed:
   - Use 50% of TDD and divide w/Meals or q6h
   - Hold orders
   - Insulin selection

IV to Subcutaneous Transition

Correction Scale
• Order correction scale
  - Use same formulation and frequency as nutritional insulin if starting feed
  - If not starting feed, use SAA q4h or regular insulin q6h
  - Order scale that fits with TDD

IV to Subcutaneous Transition

Discontinuing Infusion
• Stop infusion 2 hours after administration of Long Acting Analog
  - Onset of action of LAA insulin ~ 2 hr
  - Frequently overlooked – Pharmacists can help!

• If patient must transfer NOW:
  - May overlap by only 1 hr if short acting/regular + long acting analog given
    • Give 10% of basal dose as short-acting/regular
Patient Case - AM

- Hospital Day 3 – 0800
- Doing great, off pressors x 48 hrs
- Labs normalized, SrCr/BUN @ baseline
- Remains NPO, but will start trickle feed this PM
- Looking to transfer to Med/Surg floor
- Need to convert IV insulin for transfer

Patient Case - AM

- BGs ranging from 120 – 160 mg/dL overnight
- Hourly insulin rate 3 units/hr +/- 1 unit over past 12 hours
- D5W1/2NS + KCL 20 mEq running at 75 mL/hr for past 36 hours

How should we convert AM’s insulin regimen?

Step 1: Calculate estimated TDD
- TDD = (3 unit/hr x 24 hr x 60%) = 43.2 units/day

Step 2: Order basal insulin
- Insulin detemir/glargine: 45 units qAM. Start NOW
- Alternatively on conversion day:
  - Give half NOW (20 units), half at bedtime (25 units)
  - Start full dose at bedtime tomorrow

Patient Case - AM

- Step 3: Order nutritional insulin
  - Use 10 to 20% of basal dose
  - Order: 5 units regular insulin q6h, Start when tube feed at goal
  - Hold for:
    - BG less than 80 mg/dL
    - Tube feed off or not to goal

Patient Case - AM

- Step 4: Order correction scale based on TDD
  - Order: Medium dose correction scale, regular insulin q6h

- Step 5: Discontinue infusion
  - Order: Stop insulin infusion 2 hours after insulin detemir/glargine given

- Step 6: Hypoglycemia protocol (auto)

- Step 7: Follow up and adjust daily
Steroid Induced Hyperglycemia

- Mainly a post-prandial effect
  - Attenuates release of insulin by pancreas
- Recommend:
  - Increase TDDI calculation to 0.7 – 1 unit/kg/day
  - Split ratio 30:70, basal:bolus
  - As steroid dose tapered down, taper down bolus insulin.

Insulin Pumps

- Policy varies by institution
  - Not addressed in guidelines
- CMHC system official policy
  - Not allowed (much like home BIPAP, CPAP devices)
    - Can not be assured of service record and proper functioning
    - Rapidly changing patient mental status
    - Nurses are not trained on every pump
  - May restart immediately prior to discharge
- Actual Practice

Key References

- Society of Hospital Medicine: Quality Improvement Resource Room. Improving Glycemic Control, Preventing Hypoglycemia, and Optimizing Care of the Inpatient with Hyperglycemia and Diabetes.