

The American Association of Clinical Endocrinologists
presents

Management of Inpatient Hyperglycemia 2012

Today's Session

Special Populations



Commercial Support

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Faculty

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Disclosure

Dr. Inzucchi discloses that he has served as an expert witness for Eli Lilly Co., for a matter unrelated to insulin therapy. He also reports that his presentation will not include discussion of any investigational or unlabeled use(s) of a product.



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Management of Hyperglycemia in Hospitalized Patients: Special Populations

1. Overview
2. The Patient Receiving Enteral Nutrition
3. The Patient Receiving Parenteral Nutrition
4. The Patient on Steroids
5. The Patient on an Insulin Pump
6. Pre-Op Recommendations



Inpatient Hyperglycemia and Poor Outcomes in Numerous Settings

Study	Patient Population	Significant Hyperglycemia-Related Outcomes
Pasquel et al, 2010	Total parenteral nutrition	↑ Mortality risk, pneumonia risk, ARF
Frisch et al, 2009	Noncardiac surgery	↑ Mortality risk, surgery-specific risk
Schlenk et al, 2009	Aneurysmal SAH	↑ Mortality risk; impaired prognosis
Palacio et al, 2008	All admitted patients, children's hospital	↑ ICU length of stay (LOS), ICU admissions
Bohicchio et al, 2007	Critically injured / trauma	↑ LOS, mortality risk, ventilator time, infection
Baker et al, 2006	Chronic obstructive pulmonary disease	↑ LOS, mortality risk, adverse outcomes
McAlister et al, 2005	Community-acquired pneumonia	↑ LOS, mortality risk, complications
Umpierrez et al, 2002	All admitted patients (87% non-ICU)	↑ LOS, mortality risk, ICU admissions ↓ Home discharges

Pasquel FJ, et al. *Diabetes Care*. 2010;33:739-741; Frisch A, et al. *Diabetes*. 2009;58(suppl 1):O1-OR; Schlenk F, et al. *Neurocrit Care*. 2009;11:56-63; Palacio A, et al. *J Hosp Med*. 2008;13:12-21; Bohicchio GV, et al. *J Trauma*. 2007;63:1353-1356; Baker SI, et al. *Thorax*. 2006;63:284-289; McAlister FA, et al. *Diabetes Care*. 2005;28:810-815; Umpierrez GE, et al. *J Clin Endocrinol Metab*. 2002;87:279-283

Current recommendations for hospitalized patients

- All critically ill patients in intensive care unit settings
 - Blood glucose level 140–180 mg/dL
 - Intravenous insulin preferred
- Non-critically ill patients
 - Premeal: <140 mg/dL
 - Random: <180 mg/dL
 - Scheduled subcutaneous insulin preferred
 - Sliding-scale insulin is discouraged
- Hypoglycemia
 - Reassess the regimen if blood glucose level is <100 mg/dL
 - Modify the regimen if blood glucose level is <70 mg/dL

Moghissi ES, et al; AMZ/JADA Inpatient Glycemic Control Consensus Panel. *Endocr Pract*. 2009;15(4).
Umponree G et al. *J Clin Endocrinol Metab* 97: January 2012

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Nutrition Support: Enteral and Parenteral Nutrition

Provided to any patient that is malnourished or at risk for general malnutrition - i.e., compromised nutrition intake in the context of duration/severity of disease.

Enteral

- for patients with intact gastro-intestinal (GI) absorption.

Short term:

- Nasogastric (NG)
- Nasoduodenal
- Nasojejunal

Long term:

- PEG
- Gastrostomy
- Jejunostomy

Parenteral

- for patients with or at risk for deranged GI absorption (intestinal obstruction, ileus, peritonitis, bowel ischemia, intractable vomiting, diarrhea)

Short term:

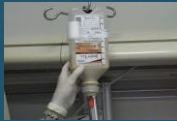
- peripheral access (PPN)
- #### Long term:
- central access (TPN)

Ukeda et al., *J Parenter and Enteral Nutr.* 2010; 25(4): 403-414

Synchronization of Nutrition Support and Metabolic Control Is Important

- **Nutrition support:** to achieve a calorie target
 - Oral (standard & preferred)
 - Enteral (gastrostomy, postpyloric, jejunostomy tubes)
 - Parenteral (IV: peripheral, central)
- **Metabolic control:** to achieve a glycemic target
 - Insulin
- **Nutrition support + Metabolic control = 'Metabolic support'**

Enteral Nutrition and Hyperglycemia

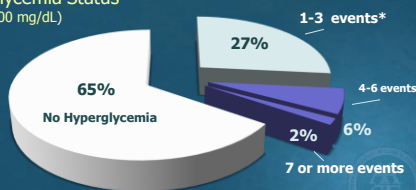


- Continuous or intermittent delivery of calorie-dense nutrients
- Wide variety of schedules and formulas
- Altered incretin physiology (?)
- Increased risk of hyperglycemia
- Basal insulin should be ideal treatment strategy, but...
- Concerns re: potential hypoglycemia after abrupt discontinuation (e.g., gastric residuals, tube pulled, etc.)
- Combined Basal-Regular strategies may be optimal

Enteral Nutrition – Diabetogenic?

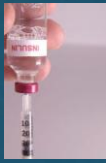
Patients in an acute care hospital on enteral feeding:
mean age 76 yrs; 54.7% female; mean days EN 15 days

Hyperglycemia Status
(*BG > 200 mg/dL)



Panrco-Hidalgo et al. J Clin Nurs 2001;10:482

Enteral Nutrition: Insulin Therapy Options



- 1) Basal insulin (Glargine, Detemir QD, NPH BID)
+ Correction (Regular or Rapid Analogue)
- 2) RISS with supplemental basal insulin if needed
- 3) Basal insulin
+ Fixed dose Regular/Rapid Analogue Q6-hr
+ Correction (Regular or Rapid Analogue)

50:50 ratio



Variable Insulin Regimens Based on Different Types of Enteral Feeding Schedules

Continuous enteral nutrition (EN)

- Basal: 40-50% of TDD as long or intermediate acting insulin given once twice a day
- Short acting 50-60% of TDD given q6h

Cycled enteral nutrition

- Intermediate acting insulin given together with a rapid or short acting insulin with start of TF
- Rapid or short acting insulin administered q4 to 6 hours for duration of EN administration
- Correction insulin given for BG above goal range

Bolus enteral nutrition

- Rapid acting analog or short acting insulin given prior to each bolus



EL4, expert opinion

Insulin & Enteral Therapy: Coverage Protocol if Tube Feeds Abruptly Stopped

1. Calculate total carb. calories being given as tube feeds.
2. Follow BG q1 hr
3. If BG < 100 mg/dl, give this amount as D5W or D10W IV.

100cc=5g

100cc=10g

Example

- Patient receiving 80cc/hr of Jevity™ enterally
- Jevity™ = 240cc/8 oz can; containing 36.5 g carb
- 1 cc Jevity ≈ 0.15 g (150 mg) carb
- @ 80cc/hr ≈ 12 g
- Give 120cc/hr D10W or 240cc/hr D5W



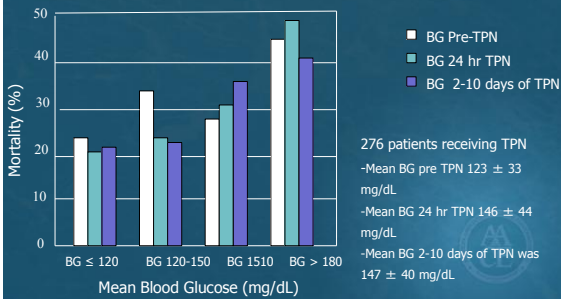
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Glycemia in Patients Receiving TPN

Mean BG and mortality rate in hospitalized patients on TPN



Pasquel et al., Diabetes Care 2010; 33:739-741

TPN, Glucose & Patient Outcomes

Study	Cheung (2005)	Lin (2007)	Sarkisian (2009)	Pasquel (2010)
Hyperglycemia definition (mg/dL)	> 164*	> 180**	≥ 180***	> 180****
Mortality OR(95%CI)	10.90 (2.0-60.5) [^]	5.0 (2.4-10.6) [^]	7.22 (1.08-48.3) [^]	2.80 (1.20 - 6.80) [^]
Any Infection OR(95%CI)	3.9 (1.2 - 12.0) [^]	3.1 (1.5 - 6.5) [^]	0.9 (0.3 - 2.5)	NA
Cardiac OR(95%CI)	6.2 (0.7 - 57.8)	1.6 (0.3 - 7.2)	1.3 (0.1 - 12.5)	NA
Acute Renal Failure OR(95%CI)	10.9 (1.2-98.1) [^]	3.0 (1.2 - 7.7) [^]	1.9 (0.4 - 8.6)	2.2 (1.0 - 4.8)
Septicemia OR(95%CI)	2.5 (0.7 - 9.3)	NA	NA	NA
Any Complication OR(95%CI)	4.3 (1.4 - 13.1) [^]	5.5 (2.5 - 12.4) [^]	NA	NA

[^] Significant at P < .05
^{*} ORs are expressed using blood glucose < 124 mg/dL as a reference category
^{**} ORs are expressed using blood glucose < 110 mg/dL as a reference category
^{***} ORs are expressed using blood glucose < 180 mg/dL as a reference category
^{****} ORs are expressed using blood glucose < 120 mg/dL as a reference category as measured within 24 hrs of PN Initiat

Kumar et al. Gastro Res Prac. 2010; doi:10.1155/2011/76720

Parenteral Nutrition

- Continuous IV delivery of high-concentrations of dextrose (20-25 gm/100 cc).
- No incretin stimulation of insulin secretion
- Hyperglycemia extremely common
- Basal insulin should be ideal treatment strategy, but...
- Concerns re: potential hypoglycemia after abrupt discontinuation (e.g., technical issues with line.)
- Does pharmacy allow insulin placed directly into TPN?



Parenteral Nutrition: Insulin Therapy Options

- 1) Basal insulin (Glargine, Detemir QD, NPH BID)
+ Correction (Regular or Rapid Analogue)
- 2) Basal insulin
+ Fixed dose Regular/Rapid Analogue Q6-hr
+ Correction (Regular or Rapid Analogue)
- 3) Regular Insulin in TPN bag may be safest approach
 - limited flexibility (wait 24-48 hrs for next bag)
 - not appropriate for Type 1 diabetes.



50:50 ratio

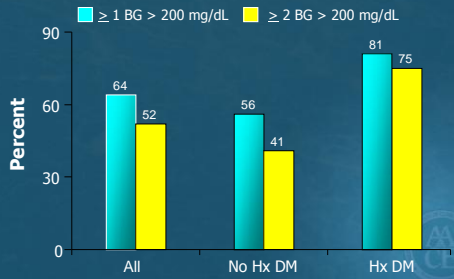


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Frequency of Hyperglycemia in Patients Receiving High-Dose Steroids



Donihi A et al. *Endocr Pract.* 2006 Jul-Aug;12(4):358-362. E12, retrospective case control study

Steroid Therapy and Inpatient Glycemic Control



- Steroids are counterregulatory hormones that impair insulin action (induce insulin resistance) and also appear to diminish insulin secretion.
- The majority of patients receiving ≥ 2 days of glucocorticoid therapy at a dose equivalent of at least 40 mg per day of Prednisone developed hyperglycemia
- No glucose monitoring was performed in 24% of patients receiving high dose glucocorticoid therapy

Donihi A et al. *Endocr Pract.* 2006 Jul-Aug;12(4):358-62. E12, retrospective case control study

General Guidelines for Glucose Control and Glucocorticoid Therapy

The majority of patients (but not all) receiving high dose glucocorticoid therapy will experience elevations in blood glucose (often marked.)

Suggested approach:

- Institute glucose monitoring for at least 48 hrs in all patients
- Prescribe insulin therapy based on bedside BG monitoring
- For the duration of steroid therapy, adjust insulin therapy to avoid uncontrolled hyperglycemia & hypoglycemia

Steroid Therapy and Glycemic Control Patients with and without Diabetes

- For patients without prior DM or hyperglycemia or those with diabetes controlled with oral agents:
 - ✓ Begin BG monitoring with low dose correction insulin scale administered prior to meals
- For patients previously treated with insulin
 - ✓ Increase total daily dose by 20 to 40% with start of high dose steroid therapy
 - ✓ Increase correctional insulin by one step (low to moderate dose)
- Adjust insulin as needed to maintain glycemic control (with caution during steroid tapers)



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Insulin Pumps



Overview of Insulin Pump Therapy



- Electronic devices that deliver insulin through a SQ catheter – basal rate (variable) + bolus delivery for meals.
- Used predominately in Type 1 diabetes.
- ‘Pumpers’ tend to be very fastidious about their glycemic control.
- They are often reluctant to yield control of their diabetes to the inpatient medical team.
- Generally speaking, hospital personnel are unfamiliar with the workings of insulin pumps.
- Hospitals do not stock infusion sets, batteries, etc. for insulin pumps (4+ brands on market.)

The Challenge of Insulin Pump Use in the Hospital

- If patient is alert and able to control pump, there is no logical reason for pump to be discontinued (and patient switched to a generally inferior insulin strategy.)
- But....many medico-legal issues!
- And...many obstacles to safe pump therapy in the hospital (trained personnel, equipment, alarms, documentation, etc)
- Therefore, all hospitals should have a policy for the safe use of insulin pumps at their facilities.

‘Insulin Pump Policy’: Main Elements

- Patient qualifications for self-management (normal mental status, able to control device, etc.)
- Pump in proper functioning order and supplies stocked by patient/family
- Patient contract / agreement to be signed
- Order set entry
- Documentation of doses delivered (pump flow sheet)
- Ongoing communication between patient and RN
- Policies re: procedures, surgeries, CTs, MRIs, etc.

Inpatient Insulin Pump Therapy: A Single Hospital Experience

- 65 patients (125 hospitalizations)
- Age (mean) 57 ± 17 yrs; DM duration 27 ± 14 yrs, pump use 6 ± 5 yrs; A1c 7.3 ± 1.3%; LOS 4.7 ± 6.3 days
- Pump therapy continued 66%
- Endocrine consults in 89%
 - Consent agreements in 83%
 - Pump order sets completed in 89%
 - RN assessment of infusion site in 89%
 - Bedside insulin pump flow sheets in only 55%
- Mean BG 175 mg/dl (same as off pump)
- No AEs (one catheter kinking)

Nassar et al. J Diab Sci Technol 2010;4:863

A Validated Inpatient Insulin Pump Protocol

- *Physician Order Set*
 - Consult Diabetes Service / Endocrinologist
 - Discontinue all previous insulin orders
 - Check capillary blood glucose frequency
 - Patient to self-administer insulin via pump
 - Patient to document all BG and basal/bolus rates
 - Insulin type order for pump: rapid-acting analogue (lispro, aspart, glulisine)
 - Set target BG range
 - Implement hypoglycemia treatment protocol

Noschese et al. Endocrin Pract 2009;15:415

A Validated Inpatient Insulin Pump Protocol

Basal Insulin Rates

Start Time	Stop Time	Basal Rate Units/hr	Start Time	Stop Time	Basal Rate Units/hr	Start Time	Stop Time	Basal Rate Units/hr
12 am	1 am	0.7	8 am	9 am	1.0	4 pm	5 pm	0.7
1 am	2 am	0.7	9 am	10 am	1.0	5 pm	6 pm	0.9
2 am	3 am	0.7	10 am	11 am	0.9	6 pm	7 pm	0.9
3 am	4 am	0.7	11 am	12 pm	0.9	7 pm	8 pm	0.9
4 am	5 am	1.0	12 pm	1 pm	0.9	8 pm	9 pm	0.9
5 am	6 am	1.0	1 pm	2 pm	0.9	9 pm	10 pm	0.9
6 am	7 am	1.0	2 pm	3 pm	0.9	10 pm	11 pm	0.7
7 am	8 am	1.0	3 pm	4 pm	0.7	11 pm	12 am	0.7

Patient to self-administer insulin via SQ insulin pump and document all basal rates.

Noschese et al. Endocrin Pract 2009;15:415

A Validated Inpatient Insulin Pump Protocol

Meal Boluses based on:

Carbohydrate count

Breakfast ___ u/per ___ gram

Lunch ___ u/per ___ gram

Supper ___ u/per ___ gram

Snacks ___ u/per ___ gram

or

Fixed doses

___ u at Breakfast

___ u at Lunch

___ u at Supper

___ u with Snacks

Correction boluses: ___ unit(s) for every ___ mg/dL over ___ mg/dL (target glucose)

Noschese et al. Endocrin Pract 2009;15:415

A Validated Inpatient Insulin Pump Protocol

- 50 patient hospitalizations after implementation of an Inpatient Insulin Pump Protocol (IIPP)

• 3 groups:	Mean BG (mg/dL)	
Group 1 - IIPP+DM consult (34)	173 ±43	} P=NS
Group 2 - IIPP alone (12)	187 ±62	
Group 3 - Usual care (4)	218 ±46	

- More inpatient days with BG>300 in Group 3 (p<0.02.)
- No differences in inpatient days with BG<70
- 1 pump malfunction; 1 infusion site problem; no SAEs
- 86% of pumpers expressed satisfaction with ability to manage DM in the hospital

Noschese et al. Endocrin Pract 2009;15:415

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Pre-Op Recommendations for Patients Admitted Day of Surgery: Oral Hypoglycemic Agents



- Withhold oral agents the morning of surgery
- Insulin is necessary to control blood glucose in patients with BG > 180 during surgery
- Oral agents can be resumed postoperatively when:
 - Patient is reliably taking PO
 - Risk of liver, kidney and heart failure are lower



Pre-op Recommendations for Patients Admitted Day of Surgery: Insulin Treated Patients



Give \approx 50% of usual dose of NPH that morning or \approx 80% of NPH, glargine, detemir insulin the night before (goal is to avoid hypoglycemia during NPO periods but also prevent pre-surgical BGs >180 mg/dl if possible)

For patients receiving premix insulin (70/30 or 75/25), give 1/3 of total dose as NPH insulin only prior to the procedure

For patients undergoing prolonged procedures (e.g. CABG) hold SQ insulin and start IV insulin infusion (will need post-op anyway)



Preoperative Recommendations: Patients using an insulin pump



- DC insulin pump and change to IV insulin according to patients current basal rate
- If basal rate < 1 unit/hr, start IV insulin at 0.5 units/h
- If basal rate 1-2 units/hr, start IV insulin at 1 units/h
- For brief/minor procedures where pump catheter insertion site is not in surgical field, may continue insulin pump, with a 20% reduction in basal rate (i.e. 1 u/hr changes to 0.8 u/hr.
- Hypoglycemia and hyperglycemia are treated in manner similar to that of patients receiving SQ insulin pre-op



Management of Hyperglycemia in Hospitalized Patients: Special Populations

SUMMARY

- Hyperglycemia is associated with adverse clinical outcomes in the hospital setting, both in critically ill and noncritically ill patients.
- National organizations have promoted safe and achievable glucose targets for inpatients.
- Special considerations are necessary for patients receiving steroids, on enteral or parenteral Nutrition, and those using insulin pumps. Pre-op guidelines are also important to optimize surgical control.

Questions



Resources for More Information

Resource	Contact Information
AACE Inpatient Glycemic Control Resource Center	http://resources.aace.com/
Georgia Hospital Association Diabetes Special Interest Group	http://www.gha.org/pha/health/diabetes/index.asp
Glucometrics Web site (free service to calculate inpatient glucose control data)	http://metrics.med.yale.edu/main/

AACE Inpatient Glycemic Control Resource Center



<http://resources.aace.com/>



Part 3 – Management of Inpatient Hyperglycemia: Safe and Effective Use of Insulin

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February 7, 2012
1130 AM Eastern
 or
1 PM Central (10 AM Pacific)

Visit <http://aes.aace.com> for more information and to register.
