

The American Association of Clinical Endocrinologists  
*presents*

## Management of Inpatient Hyperglycemia 2012

Today's Session

*Special Populations*



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## Commercial Support

AACE and The Epsilon Group would like to acknowledge the following companies that have provided support for this educational activity:

Lilly USA, LLC

Novo Nordisk Inc.



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## Faculty

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Associate Clinical Professor of Medicine  
University of California, Los Angeles

## Disclosure

**Dr. Moghissi** reports that she has provided consultation for Amylin, Boehringer Ingelheim, Eli Lilly, Novo Nordisk, and sanofi aventis. She has received speaker honoraria from AstraZeneca, Bristol-Myers Squibb and Novo Nordisk. She also reports that her 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



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## 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

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## 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

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## 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'**

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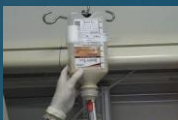
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## Enteral Nutrition and Hyperglycemia



- 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

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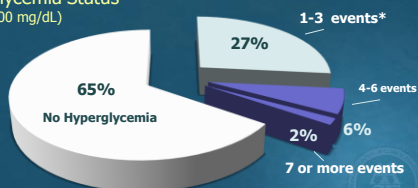
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## Enteral Nutrition – Diabetogenic?

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

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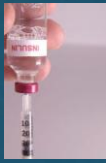
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## Enteral Nutrition: Insulin Therapy Options



- 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




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## 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

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## 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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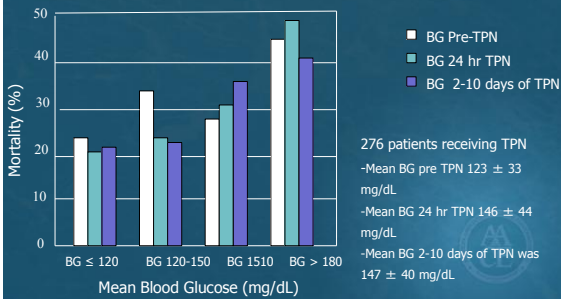
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## Glycemia in Patients Receiving TPN

Mean BG and mortality rate in hospitalized patients on TPN



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

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## 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

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## 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?



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## 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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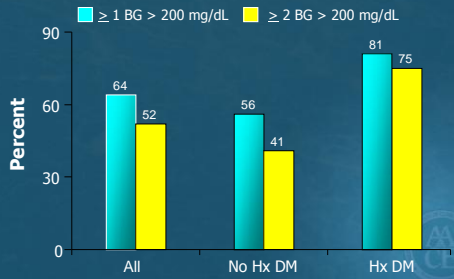
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## Frequency of Hyperglycemia in Patients Receiving High-Dose Steroids



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

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## 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  $\geq 2$  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

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## 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

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## 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



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## 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.)

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## 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.

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## ‘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.

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## 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

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## 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

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## 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

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## 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

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## 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



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## 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)



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## 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



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## 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.

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## Questions



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## Resources for More Information

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

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# AACE Inpatient Glycemic Control Resource Center



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

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

Scott Drab, PharmD, CDE, BC-ADM

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

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

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