Glycemic Control

Insulin In The Hospital Setting

Glycemic Control

- The Evidence For Insulin's Benefit
- The Mechanism of Insulin's Benefit
- The Achievement of Insulin's Benefit
- A Few Cases…

Glycemic Control In The Hospital

Major Prospective Studies

- DIGAMI Post MI
  BMJ, 1997
  - 28% Decreased All Cause Mortality
- Leuven 1 SICU
  NEJM, 2001
  - 34% Decreased In Hospital Mortality + Reduced Morbidity
- Leuvan 2 MICU
  NEJM, 2006
  - 16% Decrease In Hospital Mortality* + Reduced Morbidity

* MICU Stay > 3 Days

Glycemic Control In The Hospital
Major Prospective Studies

- Portland Post CABG
  J Thoracic CV Surg 2003
  - ~45% Decrease Mortality
- Lazar Post CABG
  Circulation, 2004
  - Major Morbidity Reduction*
- Krinsley ICU
  Mayo Clin Proc, 2004
  - 29% Decrease Mortality

* Pacing, A. Fib, Infection, Days On Vent, In ICU, In Hospital

Characteristics Of Negative Trials

- Lack Of Glycemic Separation
- Underpowered

Insulin In The Hospital Setting

The days of casual glycemic control for critically ill patients should be over!

So, Reducing Glucose Is Good!!

But how low should we go…

Glycemic Control In The Hospital

Major Prospective Studies

- DIGAMI Post MI — *BMJ, 1997* → 28% Decreased All Cause Mortality
- Leuven 1 SICU — *NEJM, 2001* → 34% Decreased In Hospital Mortality + Reduced Morbidity
- Leuvan 2 MICU — *NEJM, 2006* → 16% Decrease In Hospital Mortality* + Reduced Morbidity

* MICU Stay > 3 Days

AACE Position Statement 12/16/03: Hospital Glycemic Goals

Intensive Care Units: *110 mg/dL*

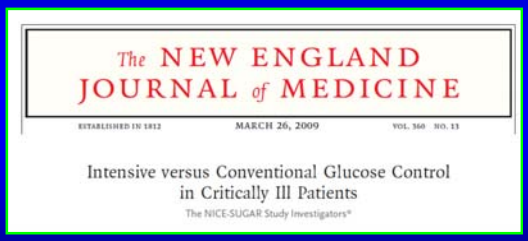
Non-Critical Care Units:

Pre-Prandial *110 mg/dL*

Max. Glucose *180 mg/dL*

NICE-SUGAR

Normoglycemia in Intensive Care Evaluation-Survival Using Glucose Algorithm Regulation



The NICE-SUGAR Study Investigators. *NEJM* 360: 1283-1297, 2009

NICE-SUGAR

Normoglycemia in Intensive Care Evaluation-Survival Using Glucose Algorithm Regulation

- 6104 Patients From ICUs of 42 Hospitals in Australia, New Zealand, and North America
- Conventional
  - Insulin Given For Glucose > 180 mg/dl and Stopped For Glucose < 144 mg/dl
- Intensive
  - Glucose Target: 81 – 108 mg/dl

The NICE-SUGAR Study Investigators. *NEJM* 360: 1283-1297, 2009

NICE-SUGAR

Normoglycemia in Intensive Care Evaluation-Survival Using Glucose Algorithm Regulation

Primary Outcome

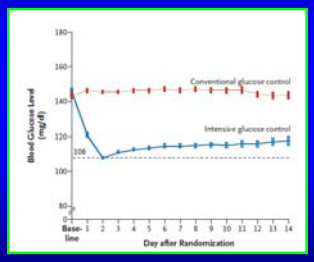
Death from Any Cause Within 90 Days After Randomization

90% Power To Detect Absolute Mortality Difference of 3.8% Assuming Baseline Mortality of 30%

The NICE-SUGAR Study Investigators. *NEJM* 360: 1283-1297, 2009

NICE-SUGAR

Normoglycemia in Intensive Care Evaluation-Survival Using Glucose Algorithm Regulation



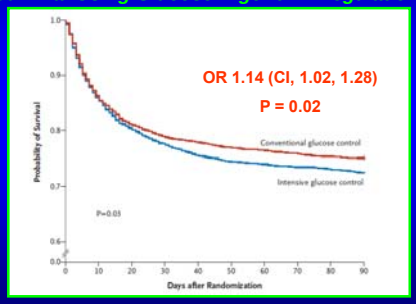
144± 23 mg/dl

115 ± 18 mg/dl

The NICE-SUGAR Study Investigators. *NEJM* 360: 1283-1297, 2009

NICE-SUGAR

Normoglycemia in Intensive Care Evaluation-Survival Using Glucose Algorithm Regulation



OR 1.14 (CI, 1.02, 1.28)

P = 0.02

The NICE-SUGAR Study Investigators. *NEJM* 360: 1283-1297, 2009

NICE-SUGAR

Normoglycemia in Intensive Care Evaluation-Survival Using Glucose Algorithm Regulation


The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Hypoglycemia and Risk of Death in Critically Ill Patients

The NICE-SUGAR Study Investigators*

The NICE-SUGAR Study Investigators. *NEJM* 367: 1108-1118, 2012

NICE-SUGAR

Normoglycemia in Intensive Care Evaluation-Survival Using Glucose Algorithm Regulation

Hypoglycemia	HR For Mortality
None	
Moderate (41-70 mg/dl)	1.41 (1.21,1.62, p < 0.001)
Severe (≤ 40 mg/dl)	2.10 (1.59, 2.77, p < 0.001)
Hypoglycemia: no insulin	3.84 (2.37, 6.23, p < 0.001)

The NICE-SUGAR Study Investigators. *NEJM* 367: 1108-1118, 2012

Insulin In The Hospital Setting

The days of casual glycemic control for critically ill patients should be over!

AACE Position Statement 12/16/03: Hospital Glycemic Goals

Intensive Care Units: *110 mg/dL*

Non-Critical Care Units:

Pre-Prandial *110 mg/dL*

Max. Glucose *180 mg/dL*

ADA/AACE Consensus Statement on Inpatient Glycemic Control 2009

- *Critically Sick Patients*
  - -Threshold to Start Insulin Therapy No Greater Than 180 mg%
  - - On Therapy Goal Is 140-180 mg%
- *Non Critically Sick Patients**
  - Pre-Meal < 140 mg%
  - Random < 180 mg%

Moghissi, E *et al Endocrine Practice* May/June, 2009
*Reaffirmed by the Endocrine Society, 2012

Take Home Points

- There is considerable evidence that good glycemic control is beneficial to critically ill patients.
- Hypoglycemia must be avoided.

Glycemic Control

- The Evidence For Insulin's Benefit
- The Mechanism of Insulin's Benefit
- The Achievement of Insulin's Benefit
- A Few Cases…

Beneficial Effects Of Insulin In The Critical Care Setting

- Hyperglycemia Is Bad
- Since Insulin Reduces Glucose, It Is Good…
- *But Beyond Glucose…*

Insulin

In The Critical Care Setting

Vasodilates
Acts As Metabolic Modulator
Enhances Cell Survival
Restrains Platelets
Promotes Fibrinolysis
Enhances Granulocyte Function
Is A Potent Anti-Inflammatory Agent

Take Home Points

- There is considerable evidence that good glycemic control is beneficial to critically ill patients.
- Hypoglycemia must be avoided.
- Beneficial effects may be mediated in part by properties of the insulin molecule itself.

Glycemic Control

- The Evidence For Insulin's Benefit
- The Mechanism of Insulin's Benefit
- The Achievement of Insulin's Benefit
- A Few Cases…

IV Insulin Infusion Protocols

IV Insulin Protocol Based On Insulin Sensitivity

Algorithm 1		Algorithm 2		Algorithm 3		Algorithm 4	
BG	Units/hr	BG	Units/hr	BG	Units/hr	BG	Units/hr
		< 60 = Hypoglycemia					
<80	Off	<80	Off	<80	Off	<80	Off
80-109	0.2	80-109	0.5	80-109	1	80-109	1.5
110-119	0.5	110-119	1	110-119	2	110-119	3
120-149	1	120-149	1.5	120-149	3	120-149	5
150-179	1.5	150-179	2	150-179	5	150-179	7
180-209	2	180-209	3	180-209	6	180-209	9
210-239	2	210-239	4	210-239	7	210-239	12
240-269	3	240-269	5	240-269	8	240-269	16
270-299	3	270-299	6	270-299	10	270-299	20
300-329	4	300-329	7	300-329	12	300-329	24
330-359	4	330-359	8	330-359	14	>330	28
>360	6	>360	12	>360	16		

IV Insulin Protocol Based On Insulin Sensitivity

Algorithm 1		Algorithm 2		Algorithm 3		Algorithm 4		Algorithm 5		Algorithm 6	
BG	units/h	BG	units/h	BG	units/h	BG	units/h	BG	units/h	BG	units/h
< 70	0.05	< 70	0.05	< 70	0.05	< 70	0.05	< 70	0.05		
70–74	0.1	70–74	0.1	70–74	0.1	70–74	0.1	70–74	0.1		
75–79	0.1	75–79	0.2	75–79	0.2	75–79	0.2	75–79	0.2		
80–84	0.2	80–84	0.2	80–84	0.3	80–84	0.3	80–84	0.3	80–84	0.3
85–89	0.3	85–89	0.4	85–89	0.4	85–89	0.5	85–89	0.6	85–89	0.6
90–94	0.4	90–94	0.6	90–94	0.7	90–94	0.8	90–94	1.0	90–94	1.2
95–99	0.5	95–99	0.8	95–99	1.1	95–99	1.4	95–99	1.9	95–99	2.3
100–104	0.7	100–104	1.1	100–104	1.8	100–104	2.4	100–104	3.3	100–104	4.3
105–109	1	105–109	1.6	105–109	3	105–109	4	105–109	6	105–109	8
110–127	1.2	110–122	2.2	110–122	4	110–122	6	110–122	7	110–127	10
128–144	1.5	122–133	2.6	123–134	5	123–134	8	123–134	8	128–144	12
145–162	1.7	134–144	3	135–147	6	135–147	9	135–159	10	145–162	14
163–179	2	145–159	3.5	148–162	7	148–162	10	160–184	12	163–179	16
180–249	3	160–184	4	163–179	7	163–179	12	185–209	14	180–214	20
250–319	4	185–209	5	180–214	9	180–214	14	210–259	18	215–249	24
320–389	5	210–249	6	215–249	11	215–249	18	260–309	22	250–319	32
≥ 390	6	≥ 250	8	≥ 250	13	≥ 250	20	≥ 310	26	≥ 320	40

Drip Off @ 120 mg/dl

Aim For 140 mg/dl

Drip On @ 160 mg/dl

Insulin Drip Algorithm

< 120	Off
120-149	1.0
150-179	1.5
180-209	2.0
210-239	2.0
240-269	3.0
270-299	3.0
300-329	4.0
Etc.	

Suppose The Patient Starts With BG = 254 mg/dl

Insulin Drip Algorithm

< 120	Off
120-149	1.0
150-179	1.5
180-209	2.0
210-239	2.0
240-269	3.0
270-299	3.0
300-329	4.0
Etc.	

Suppose The Patient Starts With BG = 254

But After One Hour The Glucose Remains About The Same

The Initial Algorithm		The Next Algorithm	
< 120	Off	< 120	Off
120-149	1.0	120-149	1.5
150-179	1.5	150-179	2.0
180-209	2.0	180-209	3.0
210-239	2.0	210-239	4.0
240-269	3.0	240-269	5.0
270-299	3.0	270-299	6.0
300-329	4.0	300-329	7.0
Etc.		Etc.	

Computer-based Insulin Infusion Protocols

Glucommander
Practical Alternative to IV Insulin Protocols

EndoTool™
Glucose Management System

FDA CLEARS MD SCIENTIFIC'S TIGHT GLUCOSE CONTROL SOFTWARE
EndoTool™ Glucose Management System Calculates Intravenous Insulin Dosing

85763
CH-20021 (MAR/17/05)
Page 1 of 1

Clarian Health Partners
Methodist | IU | Riley

Clarian GlucoStabilizer Insulin Infusion Program

Recommended IV Fluids To Prevent Hypoglycemia, Hypokalemia & Ketosis:

- ✓ Glucose: 5-10 gms/hour
- ✓ Potassium: 20 meq/L
- ✓ The Primary Service Should Choose the Type and the Rate of the Fluid Depending on the Underlying Disease

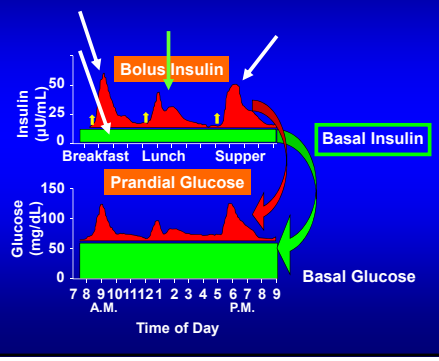
Take Home Points

- Intensive care patients, not eating or not eating very much, should be treated with continuous intravenous insulin.

Life After The Drip….

Transition From IV to SQ Insulin In The Adult Patient

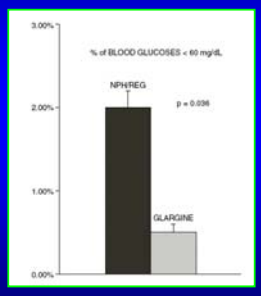
Basal - Bolus



Currently Available Basal Insulins

- Neutral Protamine Hagedorn (1946)
- Insulin Glargine (2001)
- Insuin Detemir (2006)

NPH/Reg Vs. Glargine Insulin After Cardiovascular Surgery



Yeldandi, R *et al Diabetes Technology & Therapeutics* 8: 609-616, 2006

Transition to SQ: An Approach

To Transition A Patient From An IV Insulin Infusion To SQ Insulin

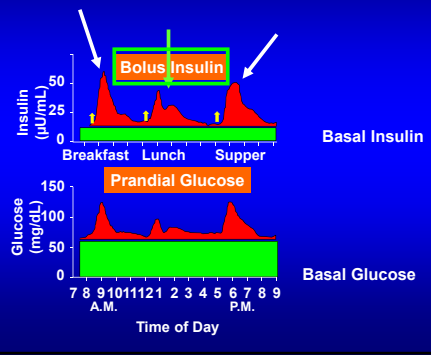
Multiply Last Drip Dose By 20, And Give This Amount As Glargine

Turn The IV Drip Off 2 Hours Later

Example: Last Drip Dose Is 1.0 Unit/Hour;
Give 1.0 X 20 = 20 Units Of Glargine SQ;
Discontinue Drip Two Hours Later

This Is Basal Insulin

Basal - Bolus



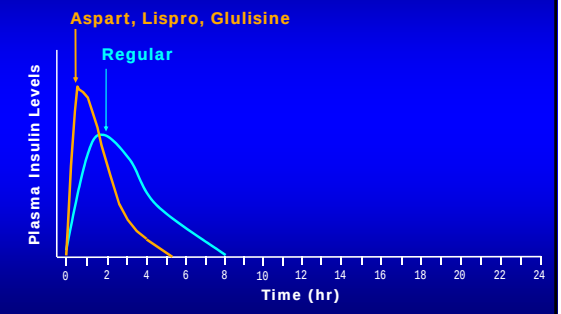
Transition From IV to SQ Insulin In The Adult Patient

- *Basal Insulin*
- *Bolus Insulin*
  - *Prandial Insulin*
  - *Correction Factor Insulin*

Currently Available Bolus Insulins

- Regular (1921)
- Insulin Lispro (1996)
- Insulin Aspart (2000)
- Insuln Glulisine (2006)

Insulin Profiles



Rosenstock J. Clin Cornerstone. 2001;4:50

First, The Prandial Dose…

When Patient Is Able To Eat,

✓ Add Rapid Acting Insulin For Mealtime Coverage

✓ *Rule Of Thumb*

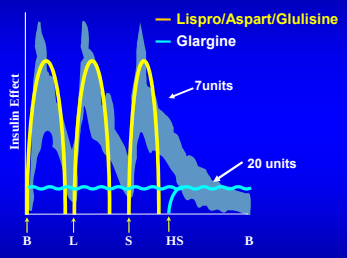
50% Basal

50% Prandial, Divided Over 3 Meals

Example: Patient Is On 20 Units Glargine Daily; Give 7 Units With Each Meal Of Lispro (Humalog) Or Aspart (Novolog) Or Glulisine (Apidra)

This Is Prandial Insulin

Basal-Bolus Insulin Therapy: Glargine at HS and Mealtime Insulin Lispro, Aspart, Or Glulisine



Transition From IV to SQ Insulin In The Adult Patient

- Basal Insulin
- Bolus Insulin

Correction Factor Insulin

Correction Factor Dose, Added To Prandial Dose

Low Dose
Total Insulin Dose <40 units/day

Premeal BG	Additional Insulin
120-170	1 unit
171-220	2 units
221-270	3 units
271-320	4 units
>320	5 units

Medium Dose
Total Insulin Dose 40-80 units/day

Premeal BG	Additional Insulin
120-170	1 units
171-220	3 units
221-270	5 units
271-320	7 units
>320	9 units

High Dose
Total Insulin Dose >80 units/day

Premeal BG	Additional Insulin
120-170	3 units
171-220	5 units
221-270	7 units
271-320	9 units
>320	11 units

What About Patients Admitted With Hyperglycemia On The Floor?

Sliding Scale

~~Episodic Bolus Insulin~~

~~WITHOUT~~

~~Basal Insulin~~

Basal Bolus Versus SSI

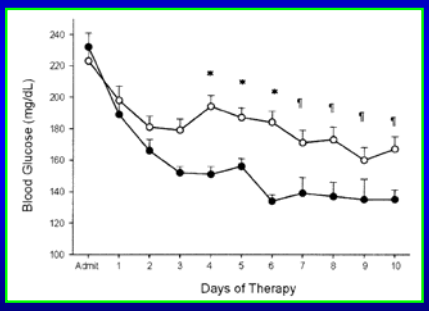
Randomized Study Of Basal-Bolus Insulin Therapy In The Inpatient Management Of Patients With Type 2 Diabetes The RABBIT 2 Trial

- 130 Type 2 Diabetic Patients Admitted to General Medicine Services
- Managed By Internal Medicine Residents Who Received A Copy Of Assigned Treatment Protocol
- Basal-Bolus Regime With Glargine And Glulisine Compared To SSI

Umpierrez, G. et al Diabetes Care 30: 2181-2186, 2007

Basal Bolus Versus SSI

Randomized Study Of Basal-Bolus Insulin Therapy In The Inpatient Management Of Patients With Type 2 Diabetes The RABBIT 2 Trial



Umpierrez, G. et al Diabetes Care 30: 2181-2186, 2007

Basal Bolus Versus SSI

Randomized Study Of Basal-Bolus Insulin Therapy In The Inpatient Management Of Patients With Type 2 Diabetes The RABBIT 2 Trial

- Glucose Difference Between Groups 27 mg% (p < 0.01)

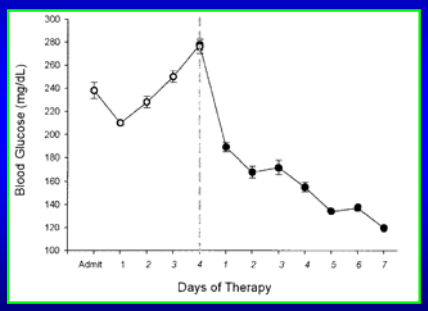
Percentage of Patients at Target (< 140 mg/dL)	
Basal - Bolus	Sliding Scale Insulin
66%	38%

- No Difference In Hypoglycemia (<0.5%)

Umpierrez, G. et al Diabetes Care 30: 2181-2186, 2007

Basal Bolus Versus SSI

Randomized Study Of Basal-Bolus Insulin Therapy In The Inpatient Management Of Patients With Type 2 Diabetes The RABBIT 2 Trial



Umpierrez, G. et al Diabetes Care 30: 2181-2186, 2007

Basal Bolus Versus SSI

The RABBIT 2 Surgery Study

- 211 Type 2 Diabetic Surgical Patients on Surgical Wards, NOT ICU
- Age 58 ± 11 Years
- Admission Glucose 190 ± 92 mg/dl
- HbA1c 7.7 ± 2.2 %
- Basal-Bolus Regime With Glargine And Glulisine Compared To SSI

Umpierrez, G. *et al Diabetes Care* 34: 256-261, 2011

Basal Bolus Versus SSI

The RABBIT 2 Surgery Study

	SSI	Basal Bolus	p
Glucose	176 ± 44	157 ± 32	< 0.001
Hypoglycemia	4.7%*	23%	< 0.001

* % of patients, but no difference in severe hypoglycemia (< 40 mg/dl

Umpierrez, G. *et al Diabetes Care* 34: 256-261, 2011

Basal Bolus Versus SSI

The RABBIT 2 Surgery Study

	SSI	Basal Bolus	p
Glucose	176 ± 44	157 ± 32	< 0.001
Hypoglycemia	4.7%*	23%	< 0.001
Composite AE	24.3%	8.6%	= 0.003

* % of patients, but no difference in severe hypoglycemia (< 40 mg/dl

Umpierrez, G. *et al Diabetes Care* 34: 256-261, 2011

Basal Bolus Versus SSI

The RABBIT 2 Surgery Study

Table 2—*Composite hospital complications and outcomes composite hospital complications*

	All	SSI	Basal-bolus insulin	*P* value
Wound infections	14	11	3	0.050
Pneumonia	3	3	0	0.247
Acute respiratory failure	6	5	1	0.213
Acute renal failure	15	11	4	0.106
Bacteremia	3	2	1	0.999
Number of patients with complications	35	26	9	0.003
Mortality	2	1	1	NS
Postsurgery ICU admission (%)	16	19.6	12.5	NS
Length of stay (days)				
ICU	2.51 ± 1.90	3.19 ± 2.14	1.23 ± 0.60	0.003
Hospital	6.8 ± 8.9	6.3 ± 5.6	7.23 ± 11.39	NS

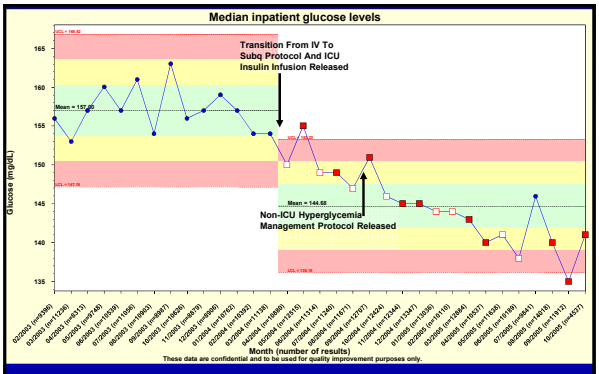
Umpierrez, G. *et al Diabetes Care* 34: 256-261, 2011

Starting Basal-Bolus From Scratch

Calculate Starting Total Daily Dose (TDD)

- ✓ Previous Total Daily Insulin Units Used or
- ✓ 0.4 units/kg (Type 1 DM)
- ✓ 0.6 units/kg (New Onset Or Lean Type 2)
- ✓ 0.8 units/kg (Type 2 DM)

This Is Very Conservative and Actual Needs May Turn Out to Be Substantially More



Definition: Median inpatient glucose levels in patients with diabetes. Glucose readings below 40mg/dL and above 400mg/dL were excluded. Data Source: Clarity database, FORCE database.

Analysis: The median inpatient glucose value, which was previously stable with a median of 157mg/dL, has decreased, and continues to decrease, with the implementation of inpatient insulin protocols.

Take Home Points

- Intensive care patients, not eating or not eating very much, should be treated with continuous intravenous insulin.
- When patients begin to eat, either in ICU or on wards, they should be transitioned to a basal bolus insulin regime.

A Word About Oral Agents….

Therapy of Type 2 Diabetes Mellitus: Hospital Use of Oral Agents

Secretagogues	Illness Decreases Endogenous Insulin
α Glucosidase Inhibitors	Not for Acute Illness With Variable Intake
Metformin	Hold for Acute Illness If Renal, Cardiac, or Liver Function Unstable, or Surgery, or Radiocontrast
Glitazone(s)	Can Give or Not

Take Home Points

- In selective, non critically ill patients, oral glycemic agents can be considered.

Have A Discharge Plan

Can A Patient Go Back To Oral Agents At Discharge?

- If Pre-Admission Control Acceptable, YES!!!
- Admission HbA1C Helpful
- If Pre-Admission Control ***Not*** Acceptable, Medication Adjustment Needed

Glycemic Control

- The Evidence For Insulin's Benefit
- The Mechanism of Insulin's Benefit
- The Achievement of Insulin's Benefit
- A Few Cases…

Floor Patient

- 65 y/o male with DM2, hyperlipidemia, HTN, and DJD
- Admitted to General Medicine with chest pain
- Metformin 1000mg BID and glipizide 5mg BID; HbA1c 6.4% 2 weeks ago
- Glucose on floor arrival 275 mg/dl
- Admit orders
  - ✓ Serial troponins
  - ✓ Possible adenosine myoview

Floor Patient

- 65 y/o male
- DM2, hyperlipidemia, HTN, and DJD
- Metformin 1000mg BID and glipizide 5mg BID
- HbA1c 6.4%
- Glucose 275 mg/dl
- Admit orders
  - ✓ Serial troponins
  - ✓ Possible adenosine myoview

What should be started to control glucose?

a) Metformin only
b) Glipizide only
c) Metformin and glipizide
d) Glargine and log
e) Insulin and metformin
f) Insulin and glipizide

Floor Patient

- 65 y/o male (75kg)
- DM2, hyperlipidemia, HTN, and DJD
- Metformin 1000mg BID and glipizide 5mg BID
- HbA1c 6.4%
- Glucose 275 mg/dl
- Admit orders
  - ✓ Serial troponins
  - ✓ Possible adenosine myoview
- Start glargine and log

What would be the insulin doses?

1)75 kg patient
2)75 x 0.8 = 60 units insulin total
3)60 / 2 = 30 units
4)30 units basal (glargine)
5)30 units prandial (log) -- 10 units after each meal
6)Medium dose correction factor

Floor Patient

- 65 y/o male (75kg)
- DM2, hyperlipidemia, HTN, and DJD
- Metformin 1000mg BID and glipizide 5mg BID
- HbA1c 6.4%
- Glucose 275 mg/dl

Patient NPO after midnight for adenosine myoview

How should insulin orders be changed once he is NPO?

a) Stop all of the insulin
b) Hold the prandial log only, continue glargine and correction scale
c) Hold the glargine only, continue log and correction scale

Floor Patient

- 65 y/o male (75kg)
- DM2, hyperlipidemia, HTN, and DJD
- Metformin 1000mg BID and glipizide 5mg BID
- HbA1c 6.4%
- Glucose 275 mg/dl

Patient NPO after midnight for adenosine myoview

Reversible defect on myoview led to stent

With which diabetes medication(s) should the patient be sent home?

a) Glargine and log
b) Metformin 1000mg BID and glipizide 5mg BID
c) Insulin pump

ICU Patient

- 65 y/o female with DM2, HTN, & hyperlipidemia
- Admitted to the MICU with sepsis
- Metformin 1000mg BID, glipizide 10mg BID q day
- HbA1c 8% 3 months ago
- Glucose on MICU arrival 230 mg/dl
- *What therapy should be started for glucose control?*
  - a. Continue metformin and glipizide
  - b. Start glargine and log
  - c. Start an insulin drip

ICU Patient

- 65 y/o female with DM2, HTN, & hyperlipidemia
- Admitted to the MICU with sepsis
- Glucose on MICU arrival 230 mg/dl
- Insulin drip started

What diabetes lab should be ordered?
a) Urine microalbumin
b) Hemoglobin A1c
c) Nothing

ICU Patient

- 65 y/o female with DM2, HTN, & hyperlipidemia
- Admitted to the with sepsis
- Glucose on MICU arrival 230 mg/dl
- Insulin drip start
- Clear liquids started

How should new diet be covered?
a) Adjust the insulin drip
b) Continue the drip, start SC log with carbohydrate counting
c) Continue the drip, restart glipizide

ICU Patient

- 65 y/o female with DM2, HTN, & hyperlipidemia
- Admitted to the with sepsis
- Glucose on MICU arrival 230 mg/dl
- Insulin drip started
- Clear liquids started
- Transferring to Gen Med

What about insulin orders?
a) Continue the insulin drip
b) Stop the drip, start sliding scale log
c) Stop drip, start glargine/log

ICU Patient

- 65 y/o female with DM2, HTN, & hyperlipidemia
- Admitted to the with sepsis
- Glucose on MIC arrival 230 mg/d
- Insulin drip start
- Clear liquids sta
- Transferring to Gen Med

What are the insulin doses, *assuming last drip dose was 1.5 units/hour*?

Glargine (1.5 units x 20 = 30 units)
Log (30 units / 3 = 10 units)
10 units after each meal
Medium dose correction factor

ICU Patient

- 65 y/o female with DM2, HTN, & hyperlipidemia
- Admitted to the with sepsis
- Glucose on MIC arrival 230 mg/d
- Insulin drip started
- Clear liquids started
- Transferring to Gen Med

What happens to the insulin drip?

Discontinue the insulin drip 2 hours after glargine injected

Former ICU, Now Floor, Patient

- 65 y/o female with DM2 and sepsis
- Glargine 30 units daily and log 10 units TID
- Medium dose correction factor
- *Daily insulin dose adjustments*
  - Take the previous day's correction factor insulin dose
  - Add to today's insulin dose

ADA/AACE Consensus Statement on Inpatient Glycemic Control 2009

- *Critically Sick Patients*
  - -Threshold to Start Insulin Therapy No Greater Than 180 mg%
  - - On Therapy Goal Is 140-180 mg%
- *Non Critically Sick Patients**
  - Pre-Meal < 140 mg%
  - Random < 180 mg%

Moghissi, E *et al Endocrine Practice* May/June, 2009
*Reaffirmed by the Endocrine Society, 2012

Correction Factor Dose, Added To Prandial Dose

Low Dose
Total Insulin Dose <40 units/day

Premeal BG	Additional Insulin
120-170	1 unit
171-220	2 units
221-270	3 units
271-320	4 units
>320	5 units

Medium Dose
Total Insulin Dose 40-80 units/day

Premeal BG	Additional Insulin
120-170	1 units
171-220	3 units
221-270	5 units
271-320	7 units
>320	9 units

High Dose
Total Insulin Dose >80 units/day

Premeal BG	Additional Insulin
120-170	3 units
171-220	5 units
221-270	7 units
271-320	9 units
>320	11 units

Former ICU, Now Floor, Patient

- 65 y/o female with DM2 and sepsis
- Glargine 30 units daily and log 10 units TID
- Medium dose correction factor
- Yesterday's Glucose values:
  - Fasting 175 mg/dl 3 units
  - Pre-lunch 190 mg/dl 3 units
  - Pre-dinner 225 mg/dl 5 units
  - HS 190 mg/dl
- 11 units of correction factor (CF) aspart given

Former ICU, Now Floor, Patient

How would you adjust today's insulin dose?

Since all readings are above target, you could add ~½ of CF to glargine and the remainder divided equally with each meal.

Former ICU, Now Floor, Patient

- 65 y/o female with DM2 and sepsis
- Glargine 30 units daily and log 10 units TID
- Medium dose correction factor

Former ICU, Now Floor, Patient

- 65 y/o female with DM2 and sepsis
- Glargine 35 units daily and log 12 units TID
- Medium dose correction factor
- Yesterday's Glucose values:
  - Fasting 120 mg/dl 1 unit
  - Pre-lunch 150 mg/dl 1 unit
  - Pre-dinner 150 mg/dl 1 unit
  - HS 180 mg/dl
- 3 units of correction factor (CF) aspart given

Former ICU, Now Floor, Patient

How would you adjust today's insulin dose?

Fasting glucose is at target, but the rest of the day is above target. So, you could add the 1/3 of the entire CF with each meal

Former ICU, Now Floor, Patient

- 65 y/o female with DM2 and sepsis
- Glargine 35 units daily and log 12 units TID
- Medium dose correction factor

Former ICU, Now Floor, Patient

- 65 y/o female with DM2 and sepsis
- Glargine 35 units daily and log 13 units TID
- Medium dose correction factor
- Yesterday's Glucose values:
  - Fasting 115 mg/dl
  - Pre-lunch 118 mg/dl
  - Pre-dinner 119 mg/dl
  - HS 170 mg/dl
- No correction factor (CF) aspart given

Former ICU, Now Floor, Patient

- Patient going home!!
- On Glargine and aspart
- HbA1c 9%

How should her diabetes medication(s) be adjusted?

a) Discontinue insulin and restart oral medications
b) Reintroduce metformin to insulin
c) Continue insulin only

Special Situations

- Patients Receiving Corticosteroids
- Patients Receiving Tube Feeds
- Patients With Renal Failure

Patient on Glucocorticoids

Glucocorticoid Effects on Glucose Metabolism

- Increased hepatic gluconeogenesis increases fasting glucose
- Inhibition of glucose uptake especially in adipose tissue increases post-prandial glucose
- Predominant effect is post-prandial, so glucose rises during the day

Take Home Points

- In selective, non critically ill patients, oral glycemic agents can be considered.
- In glucocorticoid treated patients, consider giving more than 50% as bolus.
- Consider NPH instead of glargine in patients on shorter acting glucocorticoids.

Special Situations

- Patients Receiving Corticosteroids
- Patients Receiving Tube Feeds
- Patients With Renal Failure

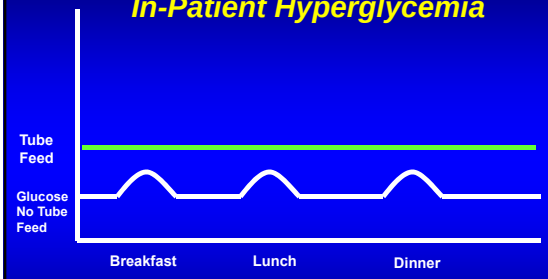
The Impact of Tube Feed on In-Patient Hyperglycemia

Continuous And Persistent Carbohydrate Absorption

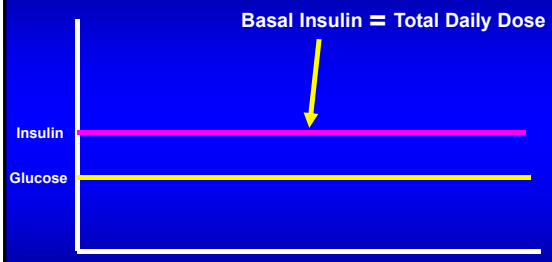
Continuous And Persistent Hyperglycemia

The Basal/Bolus Rule Is Different…..

The Impact of Tube Feeding on In-Patient Hyperglycemia



Tube Feeding And In-Patient Hyperglycemia



Continuous Tube Feed

Patients on Continuous Tube Feed

- Check Blood Glucose Every 6 Hours
- Give Correction Factor Rapid Acting Insulin Based On Algorithms

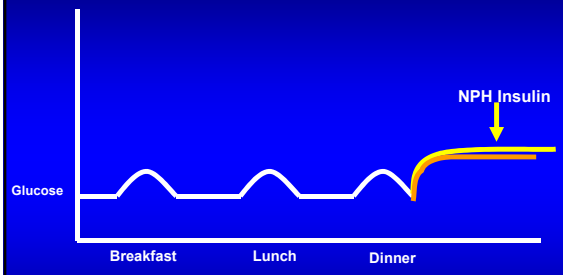
Patients on Continuous Tube Feed

- **Decrease Total Dose**
  - 10% If Glucose Level < 120 mg/dl
  - 20% Glucose Level < 80 mg/dl
- **Increase Total Dose**
  - By Adding The Total Dose Of Correction Factor Insulin The Previous Day

BEWARE of HYPOGLYCEMIA

- High Risk Of Hypoglycemia If Tube Feed Temporarily Stopped
- ***Immediately Initiate IV Fluids To Provide The Amount Of Glucose That Was In The Tube Feeding***

Tube Feed at Bedtime



Patient on Continuous Tube Feeding

- 71 year old male with type 2 diabetes recovering from massive CVA leaving him unable to swallow
- His outpatient glycemic regime consisted of oral agents only, no insulin
- He is receiving continuous tube feeding
- He weighs 180 lbs (82 kg)

How would you begin to develop his insulin regime?

Starting Basal-Bolus From Scratch

Calculate Starting Total Daily Dose (TDD)

- ✓ Previous Total Daily Insulin Units Used or
- ✓ 0.4 units/kg (Type 1 DM)
- ✓ 0.6 units/kg (New Onset Or Lean Type 2)
- ✓ 0.8 units/kg (Type 2 DM)

Starting Basal-Bolus From Scratch

Calculate Starting Total Daily Dose (TDD)

- ✓ Previous Total Daily Insulin Units Used or
- ✓ *0.5* units/kg (Type 1 DM)
- ✓ *0.8* units/kg (New Onset Or Lean Type 2)
- ✓ *1.0* units/kg (Type 2 DM)

Patient on Continuous Tube Feeding

- Weight based total daily dose of insulin would be 1.0 units/kg X 82 kg = 82 units
- So, give 82 units glargine as basal
- There is no bolus
- There is, however, correction factor; high dose correction factor

Correction Factor Dose, Added To Prandial Dose

Low Dose
Total Insulin Dose <40 units/day

Premeal BG	Additional Insulin
120-170	1 unit
171-220	2 units
221-270	3 units
271-320	4 units
>320	5 units

Medium Dose
Total Insulin Dose 40-80 units/day

Premeal BG	Additional Insulin
120-170	1 units
171-220	3 units
221-270	5 units
271-320	7 units
>320	9 units

High Dose
Total Insulin Dose >80 units/day

Premeal BG	Additional Insulin
120-170	3 units
171-220	5 units
221-270	7 units
271-320	9 units
>320	11 units

Patient on Continuous Tube Feeding

- Patient on 82 units glargine
- Yesterday's Sugars — CF Aspart
  - 6 AM — 210 mg/dl — 5 units
  - Noon — 280 mg/dl — 9 units
  - 6 PM — 290 mg/dl — 9 units
  - Midnight — 310 mg/dl — 9 units
- 32 units correction factor aspart

How would you adjust today's insulin dose?

Patient on Continuous Tube Feeding

- Patient on 114 units glargine (may split)
- Yesterday's Sugars — CF Aspart
  - 6 AM — 180 mg/dl — 5 units
  - Noon — 250 mg/dl — 7 units
  - 6 PM — 270 mg/dl — 7 units
  - Midnight — 280 mg/dl — 9 units
- 28 units correction factor aspart

How would you adjust today's insulin dose?

Patient on Continuous Tube Feeding

- Patient on 142 units glargine (may split)
- Yesterday's Sugars — CF Aspart
  - 6 AM — 135 mg/dl — 3 units
  - Noon — 155 mg/dl — 3 units
  - 6 PM — 160 mg/dl — 3 units
  - Midnight — 170 mg/dl — 3 units
- 12 units correction factor aspart

How would you adjust today's insulin dose?

Patient on Continuous Tube Feeding

- Patient on 154 units glargine (may split)
- Yesterday's Sugars — CF Aspart
  - 6 AM — 110 mg/dl — 0 units
  - Noon — 115 mg/dl — 0 units
  - 6 PM — 119 mg/dl — 0 units
  - Midnight — 119 mg/dl — 0 units
- 0 units correction factor aspart

How would you adjust today's insulin dose?

Take Home Points

- In tube fed patients, give basal and correction factor. There is no bolus *per se*.

Special Situations

- Patients Receiving Corticosteroids
- Patients Receiving Tube Feeds
- Patients With Renal Failure

The Impact Of Renal Failure On In-Patient Hyperglycemia

- ✓ Decreased Insulin Clearance
- ✓ Decreased Gluconeogenesis
- ✓ *Both Increase The Risk Of Hypoglycemia*

Reduce Dose For Renal Insufficiency

GFR cc/min	Total Insulin Dose
>30	No Change
15-29	Reduce to 70%
<15 or Dialysis	Reduce to 50%

Take Home Points

- In tube fed patients, give basal and correction factor. There is no bolus *per se*.
- Remember to consider e GFR in those with impaired kidney function.

Special Situations

- Patients Receiving Corticosteroids
- Patients Receiving Tube Feeds
- Patients With Renal Failure

Take Home Points

- There is considerable evidence that good glycemic control is beneficial to critically ill patients.
- Hypoglycemia must be avoided.
- Beneficial effects may be mediated in part by properties of the insulin molecule itself.

Take Home Points

- Intensive care patients, not eating or not eating very much, should be treated with continuous intravenous insulin.
- When patients begin to eat, either in ICU or on wards, they should be transitioned to a basal bolus insulin regime.

Take Home Points

- In selective, non critically ill patients, oral glycemic agents can be considered.
- In glucocorticoid treated patients, consider giving more than 50% as bolus.
- Consider NPH instead of glargine in patients on shorter acting glucocorticoids.

Take Home Points

- In tube fed patients, give basal and correction factor. There is no bolus *per se*.
- Remember to consider e GFR in those with impaired kidney function.

Glycemic Control

- The Evidence For Insulin's Benefit
- The Mechanism of Insulin's Benefit
- The Achievement of Insulin's Benefit
- A Few Cases…