
Practical Management of Hyperglycemia and Diabetes in the Hospital Setting

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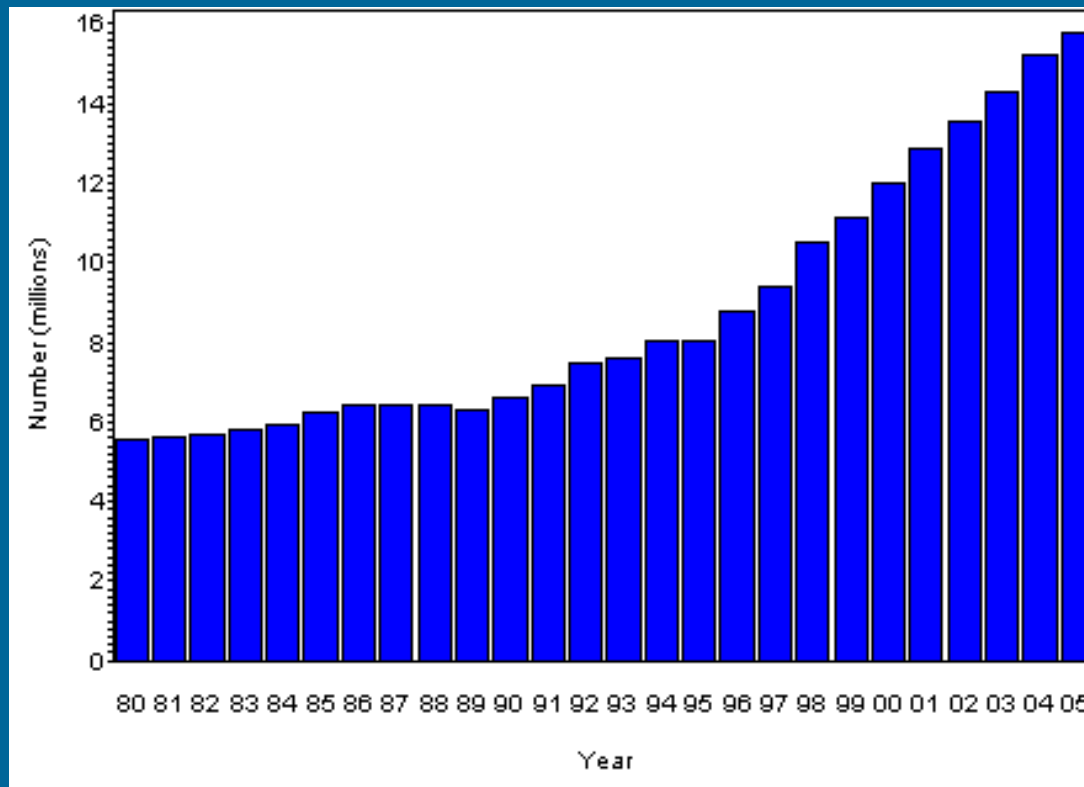
Duke University Medical Center

April 1, 2008

Diabetes Statistics

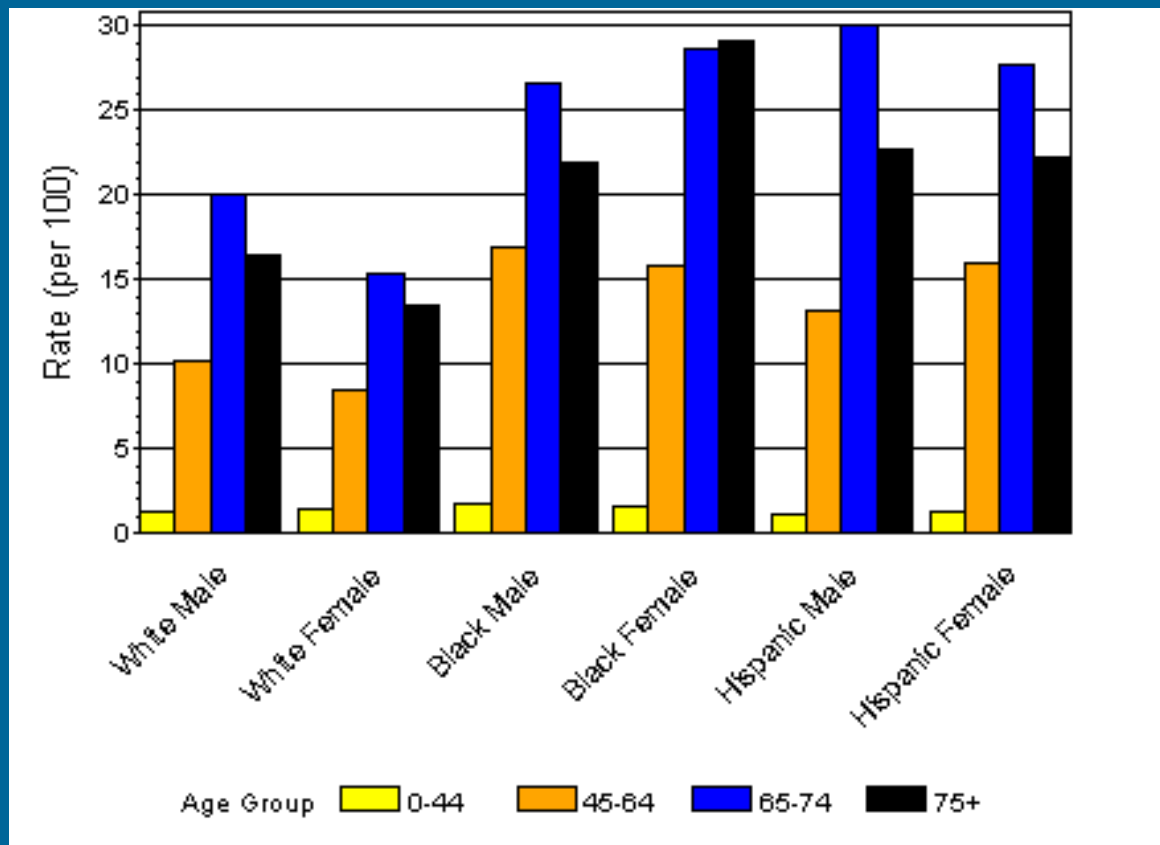
- 20.8 million US residents (7%) with diabetes
- 54 million additional with pre-diabetes
- 584,000 people in North Carolina have diabetes
- 6.2 million undiagnosed persons with diabetes
- Risk of developing diabetes at younger age than previously
- 1.5 million new cases of diabetes were diagnosed in people aged 20 years or older in 2005

Number (in Millions) of Persons with Diagnosed Diabetes, U.S. 1980–2005



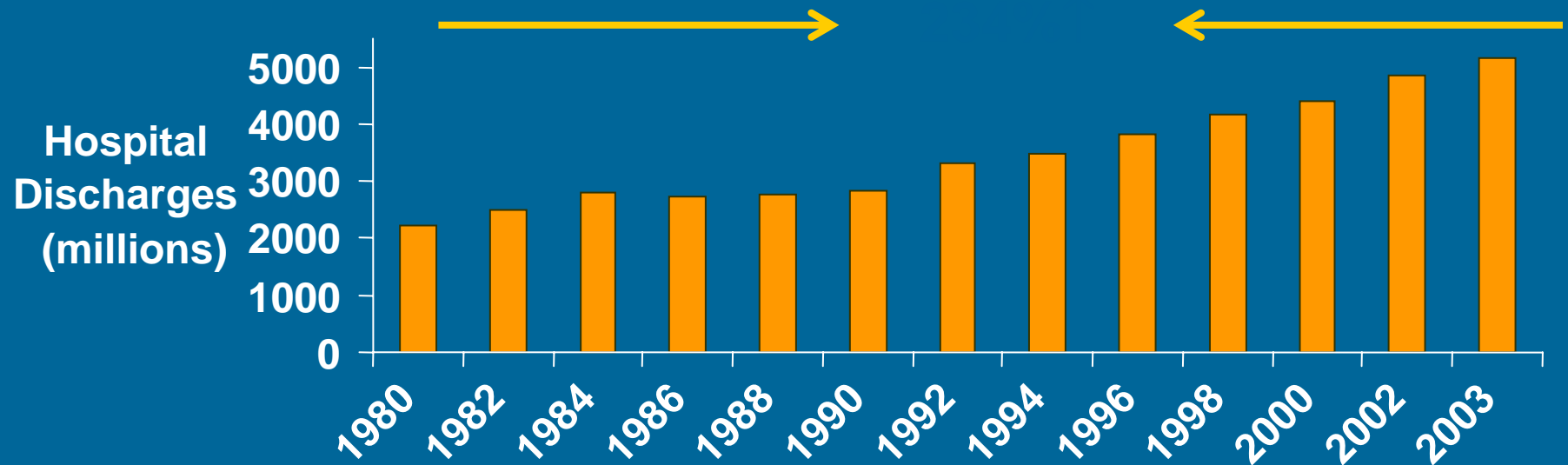
People aged 65 years or older account for approximately 38% of the population with diabetes

Age-Specific Prevalence of Diagnosed Diabetes, by Race/Ethnicity and Sex, United States, 2005



Number (in Thousands) of Hospital Discharges with Diabetes in U.S. 1980–2003

Hospitalizations for Diabetes
as a Listed Diagnosis



From 1980 through 2003, the number of hospital discharges with diabetes as any-listed diagnosis more than doubled (from 2.2 million to 5.1 million discharges)

Hyperglycemia in Patients With Undiagnosed Diabetes

- Hyperglycemia occurred in 38% of patients admitted to the hospital
 - 26% had known history of diabetes
 - 12% had no history of diabetes
- Newly discovered hyperglycemia was associated with:
 - Higher in-hospital mortality rate (16%) compared with patients with a history of diabetes (3%) and patients with normoglycemia (1.7%; both $P < .01$)
 - Longer hospital stays; higher admission rates to intensive care units (ICUs)
 - Less likely to be discharged to home (required more transitional or nursing home care)

Outcomes Correlate with Hyperglycemia After Stroke

Outcome	Blood Glucose at Admission		P value
	BG <130 (n=385)	BG ≥130 (n=258)	
Length of stay (days ± SE)	6 ± 0.3	7.2 ± 0.4	.015
Discharged to home	79%	73%	.07
In-hospital mortality	5%	7%	.15
30-Day mortality	5%	10%	.018
1-Year mortality	11%	18%	.009
6-Year mortality	22%	28%	.07
Median total charges	\$5262	\$6611	<.001

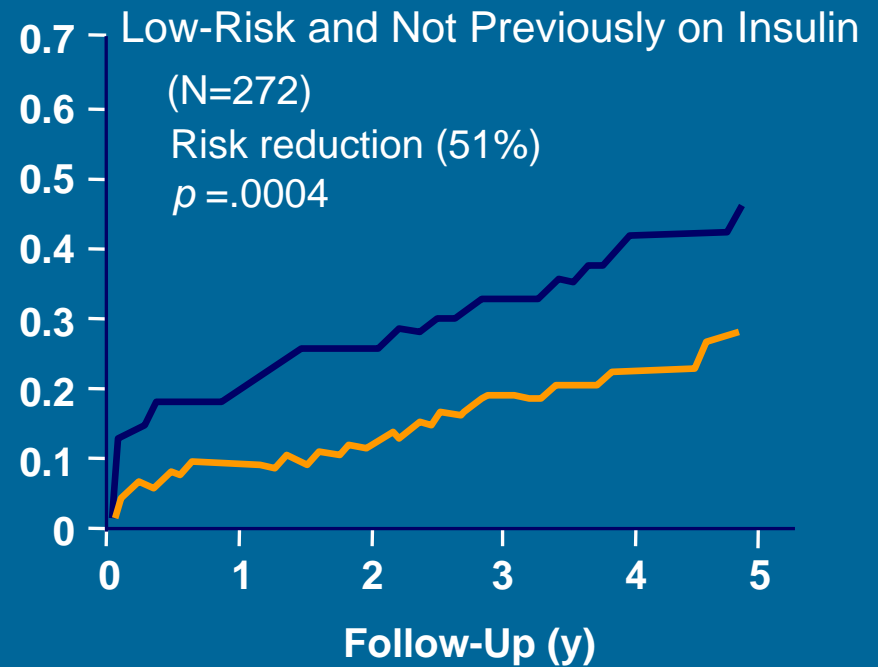
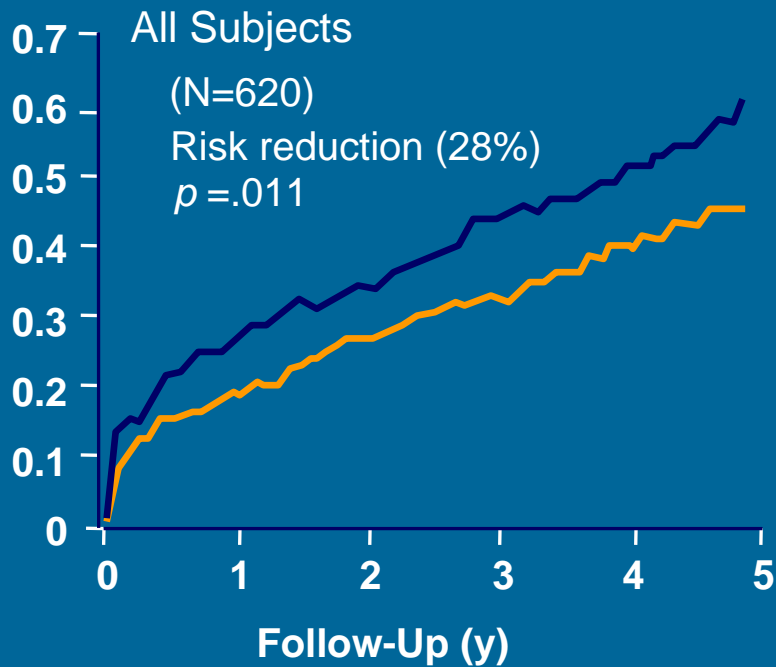
Summary

- Inpatient hyperglycemia is common
 - Inpatient hyperglycemia is associated with poor clinical outcome
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Does Controlling Inpatient
Hyperglycemia Matter?

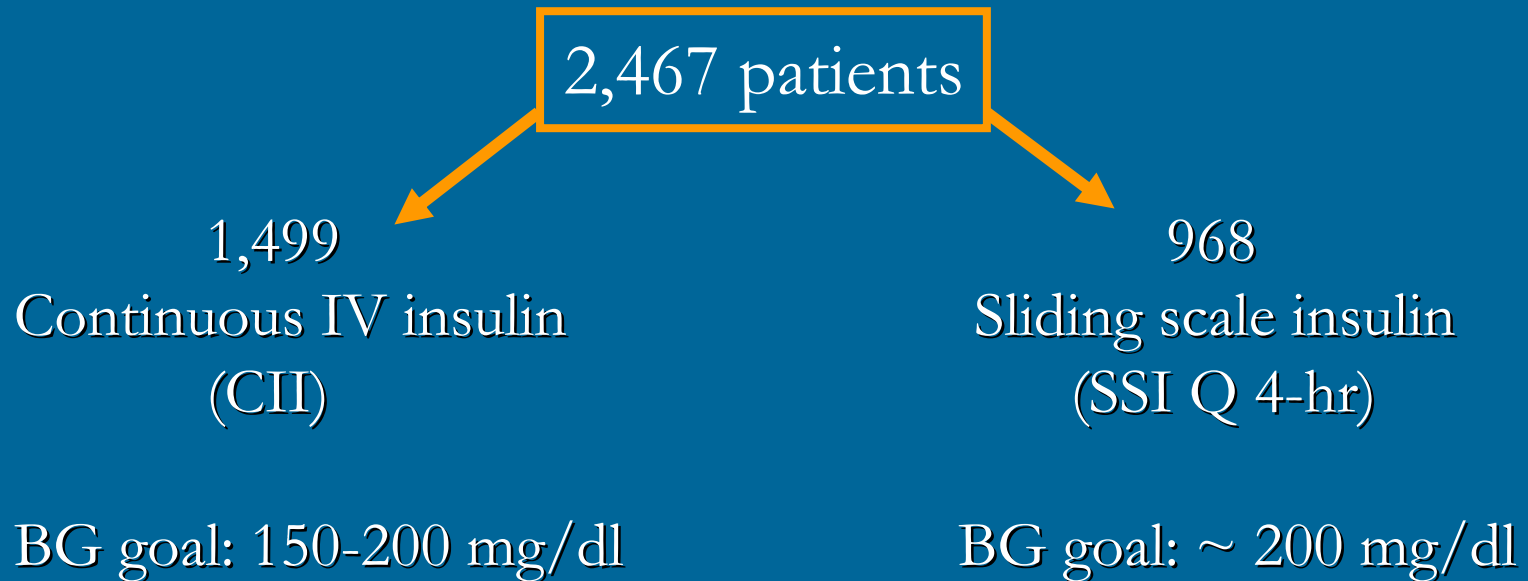
DIGAMI

- Standard treatment
- IV insulin 48 hours, then 4 injections daily



Insulin Infusion Reduces Wound Infections In Diabetic Patients After Cardiac Surgery

Prospective study of 2,467 consecutive diabetics who underwent open heart surgery between 1/87-11/97.



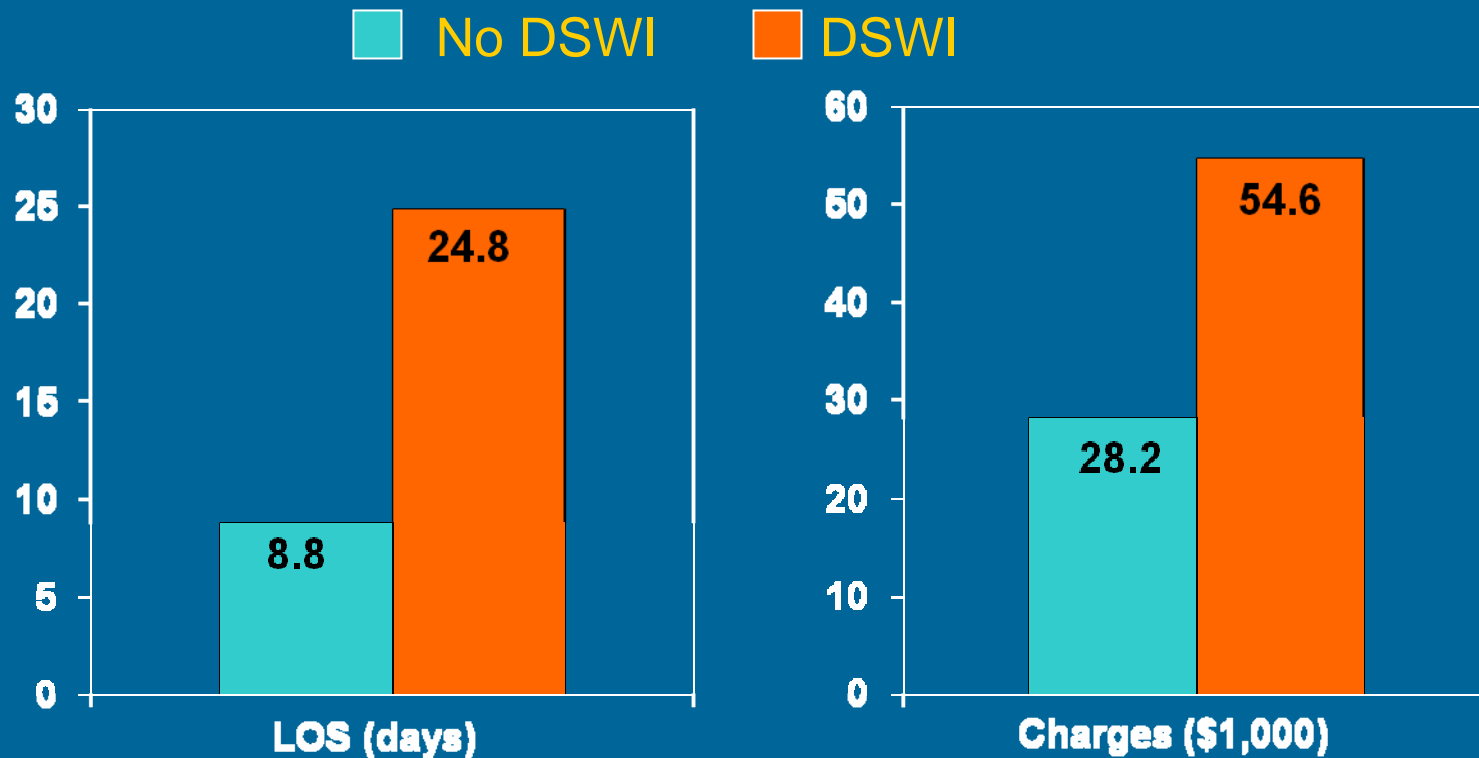
Deep Sternal Wound Infection in Diabetic Pts after Cardiac Surgery

	SQI	CII	<i>p</i> Value
# patients	968	1499	
Mean age	65	65	0.9
Admission BG (mg/dl)	194	192	0.5
DSWI (%)	1.9	0.8	0.01
Transfused RBC (units)	2.2	1.6	0.001
Inotropes > 48 h(%)	14	10	0.004
Length of Stay (days)	10.7	8.5	0.0001
Mortality (%)	6.1	3.0	0.03

DSWI: deep sternal wound infection

Deep Sternal Wound Infection: Associated LOS and Cost Consequences

Costs of Deep Sternal Wound Infection =
16 Days and \$26,000 per patient



Intensive Insulin Therapy in Critically Ill Patients: The Leuven Study

- Randomized controlled trial: 1,548 pts admitted to a surgical ICU. Pts were assigned to receive either:
 - **Conventional therapy:** IV insulin if BG > 215 mg/dL
 - Target BG levels: 180-200 mg/dL
 - Mean daily BG: 153 mg/dL
 - **Intensive therapy:** IV insulin if BG > 110 mg/dL
 - Target BG levels : 80-110 mg/dL
 - Mean daily BG: 103 mg/dL
- Repeated in medical ICU

Effects of Intensive Insulin Therapy in the ICU – van den Berghe studies

	<u>Surgical ICU¹</u>	<u>Medical ICU²</u>
Mortality	Decreased	Not Decreased
Morbidity		
Acute Kidney Injury	Decreased	Decreased
Critical Illness Polyneuropathy	Decreased	(Not Reported)
Prolonged Ventilatory Support	Decreased	Decreased
ICU Stay	Decreased	Decreased
Hospital Stay	Not Decreased	Decreased

¹Van den Berghe G, et al. *N Engl J Med* 345:1359, 2001.

²Van den Berghe G, et al. *N Engl J Med* 354:449, 2006.

Effects of Intensive Insulin Therapy in the ICU – van den Berghe studies

	<u>Surgical ICU¹</u>	<u>Medical ICU²</u>
Morbidity (continued)		
Bacteremia	Decreased	Not Decreased
Prolonged Antibx	Decreased	Not Decreased
Need for Dialysis	Decreased	Not Decreased
Hyperbilirubinemia	Decreased	Not Decreased
Red Blood Cell Tx	Decreased	Not Reported
Use of ICU Resources	Decreased	Not Decreased
Hypoglycemia	Increased	Increased

¹Van den Berghe G, et al. *N Engl J Med* 345:1359, 2001.

²Van den Berghe G, et al. *N Engl J Med* 354:449, 2006.

Cost Savings with Hospital Hyperglycemia Management

- Furnary¹ – \$5,580 per CABG patient per stay (LOS and DSWI)
- Van den Berghe² – € 2,638 per patient per ICU stay (average ICU stay: 8.6 days conventional treatment vs. 6.6 days intensive treatment)
- Krinsley³ – \$1.3M annual cost savings for a 305-bed community based hospital (14-bed ICU)

¹ Furnary AP, et al. *Endocr Pract.* 2004;10(Suppl 2):21-33.

² Van den Berghe G, et al. *Crit Care Med.* 2006;34:612-616.

³ Krinsley IS, et al. *Chest.* 2006;129:644-650.

Why lower blood glucose inpatient?

- Prevent endocrine emergencies
 - DKA
 - HHNK
 - Improve patient outcomes
 - Morbidity
 - Mortality
 - Decrease Costs
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AACE - Recommended BG Targets

- Upper Limit Inpatient Glycemic Targets:
 - ICU: 110 mg/dl (6.1 mmol/L)
 - Non-critical care (limited data)
 - Pre-prandial: 110 mg/dl (6.1 mM)
 - Maximum: 180 mg/dL (10 mM)
 - OB
 - Pre-prandial and during labor and delivery: 100 mg/dL
 - One hour postprandial: 120 mg/dL

The current ADA guideline for pre-prandial plasma glucose levels is 90–130 mg/dl

Summary

Treating Hyperglycemia Improves
Patient Outcomes

**How Do You Control
Hyperglycemia and Diabetes in
the Hospital?**

Limitations of Outpt Therapies for In-Hospital Hyperglycemia

- Diet/exercise
 - Not feasible during acute illness
- Oral agents
 - Sulfonylureas -Hypoglycemia
 - Metformin -Lactic acidosis- accumulation if rising Cr
 - Thiazolidinediones - Fluid retention, caution in CHF, delay in onset 4-6 weeks
- In general, oral agent therapy is not appropriate in the inpatient setting



American College of Endocrinology and American Diabetes Association Consensus Statement on Inpatient Diabetes and Glycemic Control

A call to action

Diabetes Care. 2006;29:1955-1962.

Recommendations of Task Force January 30-31, 2006

“Insulin, given either intravenously as a continuous infusion or subcutaneously, is currently the only available agent for effectively controlling glycemia in the hospital.”

ACE Position Statement on Inpatient Diabetes and Metabolic Control, 2004.

Question?

- My patient takes oral agents to treat his diabetes at home. He is now NPO, I'm just going to put him on “sliding scale insulin.”
- **Diabetes exists even when patients are NPO**
- In a pt with HTN, would you order medications to be given only when BP > 180/90.....or
- In a pt with infection, would you order Antibx only when temp > 38.5.....
- Hmmm – why order insulin only when BG > 150.



Sliding Scale Insulin

- Supplemental Scale Insulin is just that – it supplements a standing insulin dose
- Should be known as correction dose insulin
- If dosed correctly it is the amount of insulin to correct an elevated BG to an acceptable target.
- Rapid acting insulin is the most acceptable
- General rule - 5% of Total Daily Dose of Insulin for each 50 mg/dl BG > target

Initiating an Insulin Regimen

- What type of diabetes?
 - **TALK TO THE PATIENT**
 - Insulin regimens often change fast!
 - Interpret what they are taking...not always easy
 - Ask about any barriers to taking medication
-

Talking with Patients about Insulin

- Talk about insulin use while inpatient and after discharge
 - Flexible eating pattern based on personal preferences and schedule.
 - Individuals receiving intensive insulin therapy should adjust their pre-meal insulin doses based on the carbohydrate content of meals.
 - Fixed eating pattern determined by pre-prescribed dose and type of insulin.
 - Individuals receiving fixed daily insulin doses should try to be consistent in day-to-day carbohydrate intake.
- Does your diabetes control you or do you control your diabetes?

Assess the efficacy of the home regimen

There is little point in sending a patient home on a regimen that has not been effective

A1c (%)	Mean plasma glucose (mg/dL)
6	135
7	170
8	205
9	240
10	275
11	310
12	345

Basal – Bolus Insulin

- Basal insulin – the amount of insulin necessary to regulate blood glucose when completely NPO (approx 0.8-1unit/hr)
 - Bolus insulin – the amount of insulin needed before a meal to regulate blood glucose rise after eating
 - Basal and Bolus insulin used in combination to provide 24 hours blood glucose control
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Don't be this guy!



Determining Initial Insulin Dosing

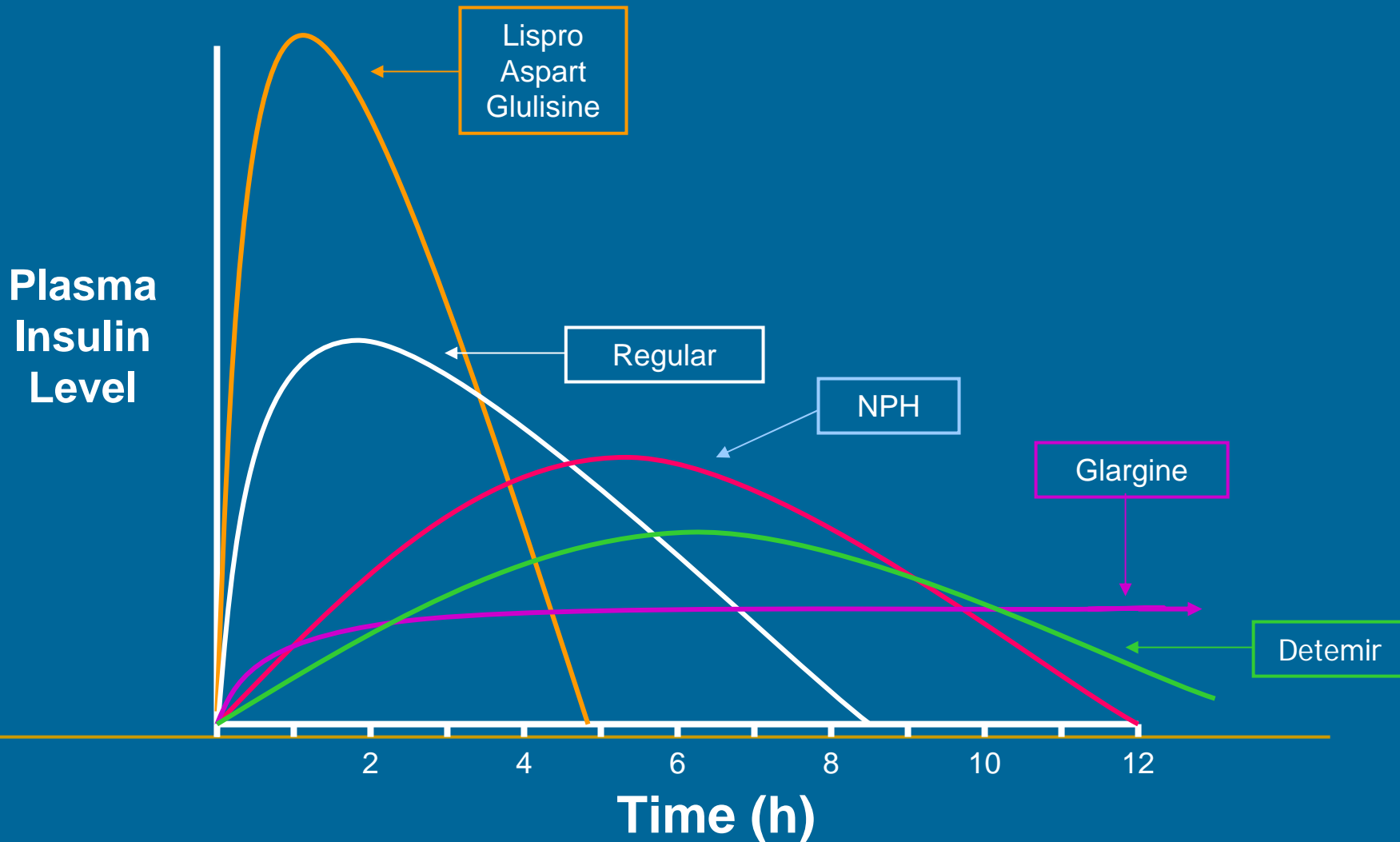
- 0.1 – 0.3 units/kg/day divided into 4 shots
 - Insulin naïve
 - Low insulin resistance (thin, diet controlled)
- 0.5 – 1.0 units/kg/day → 4 shots
 - Higher insulin resistance (High stress, Obese)
 - Long-standing, poorly controlled DM
- Point system:
 - Each 30 kg >100 kg, greater than five years of DM, multiple oral medications, and steroids add 0.1 unit/kg
 - CKD, ARF, elderly, hypoglycemia unaware subtract 0.1 unit/kg

Insulin Distributions for Inpatient

B	L	D	HS	Comments
RA	RA	RA	LA	$\frac{1}{2}$ RA ac (split), $\frac{1}{2}$ LA
R	R	R	N	$\frac{1}{4}$ R ac, $\frac{1}{4}$ N hs
Q6				
R	R	R	R	$\frac{1}{4}$ R q6

R = regular, RA = rapid acting, LA = long acting, N = NPH

Insulin Dynamics



RABBIT 2 Trial

- Randomized
 - BG 140-200 – TDD 0.4 units/kg
 - BG 201-400 – TDD 0.5 units/kg
- vs. SSI 4 times/day BG > 140
- Goal FBG and pre-meal BG < 140
- Compared mean daily BG
- 2nd outcomes – hypo, severe hyper, LOS, mortality

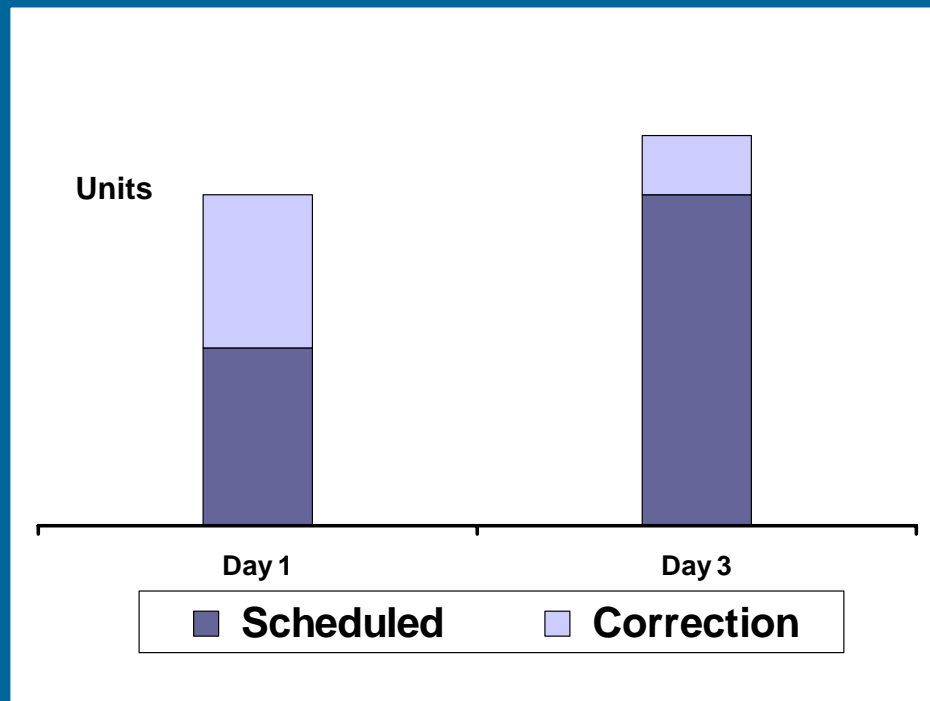
RABBIT 2 outcomes

	Basal-Bolus	SSI
LOS	5.1 ± 4	5.3 ± 6
Mean FBG	147 ± 36	165 ± 41
Mean Random	164 ± 35	189 ± 42
Mean on d/c	140	187
# hypo (<60)	2	2
% at goal	66%	38%

Adjusting SQ insulin

- Assess the total amount of insulin the patient received on the previous day
- Assess overall glucose control previous day
 - Did the patient require correction dose of insulin or have a low BG
 - ALWAYS look at fasting BG
- If close to goal increase TDD by 10% over the previous days total
- If BGs significantly elevated (>200) increase by 20%

Correction therapy



- Correction insulin signals the need to change scheduled dose of insulin in order to prevent ongoing hyperglycemia

Mel's tips

- FOLLOW UP, be available and ready to adjust insulin frequently after transitioning or adjusting
- Talk with nursing staff, provide education and let them know you are a resource
- Call orders if BG elevated (don't wait until BG > 400 to be notified)



Renal failure, elderly, Type 1,
and hypoglycemic unaware

Case Example

Time	Bkfst	Lunch	Dinner	HS
BG	156	173	198	213
Insulin	10R	10R	10R	10N
SSI	2R	2R	2R	
BG	176	193	144	132
Insulin	10R	14R	14R	14N
SSI	2R	2R		
BG	105	156	122	112
Insulin	14R	14R	14R	14N
		2R		

Case Example

Time	Bkfst	Lunch	Dinner	HS	0300
BG	105	156	122	112	
Insulin	14R	14R	14R	14N	
SSI		2R			
BG	196	134	131	123	42
Insulin	14R	14R	14R	14N	
SSI	2R				
BG	182				
Insulin					
SSI					

IV Insulin in Hospitalized Patients

- IV insulin infusions were specifically designed for in-hospital use
- For safety nothing beats the use of continuous IV insulin
 - “the gtt is an under appreciated tool”
-Lekshmi Nair, MD
- IV insulin has a short half-life (<10 minutes) and should not be discontinued until subcutaneous medication has been initiated
- Bolus IV insulin is not appropriate for blood glucose control unless accompanied by continuous infusion

Preventing Hypoglycemia

- Hypoglycemia - primary limiting factor for achieving optimal glucose control
- Reduction of insulin dose may be required if
 - Switched to NPO status or reduction in po intake
 - Enteral feedings discontinued or reduced
 - TPN or Large dose IV dextrose discontinued
 - Reduction in corticosteroid administration
- Glucose monitoring should be increased in the event of any of these (above) special circumstances

Condition	Blood Glucose Monitoring
IV insulin	q1hour – may Δ to q2h when BG within 100-150 mg/dl for 4 consecutive hours. If BG < 100 mg/dl or >150 mg/dl monitoring MUST return to q1h.
New TPN or tube feeding (when blood glucose monitoring not already ordered)	q6hours X 72hrs. If all glucoses <100 x72h, then nursing to d/c blood glucose monitoring; otherwise continue monitoring until TF d/c'd. If any glucose >150mg/dl, call provider for insulin orders. Consider DMS consult.
TPN or tube feeding receiving insulin	q6hours: if TF held, obtain BG q3hours X 2 (from last check), then resume q6hour monitoring (provided BG \geq 70); notify provider if BG <70 while TF held.
NPO or q6hour Regular insulin	q6hours
Regular, NPH, 70/30, 75/25 or any other combination insulin	ac, hs, and 0300
Glargine (Lantus) insulin and/or rapid acting insulins (aspart, glulisine, or lispro)	ac and hs

Safety with insulin

- **Subcutaneous Insulin Advisor in CPOE:**
 - 1/2 dose Regular insulin and 1/2 dose NPH in am if NPO
 - 1/2 dose scheduled insulin if BG < 70
 - give full dose of NPH at hs even if NPO
 - Always give full dose Lantus and hold rapid acting insulins (aspart, lispro, apidra) if NPO
- **Protocol for treating hypoglycemia:**
 - 15 g CHO (1 juice or 1/2 amp D50) and recheck in 30 minutes
 - Rarely appropriate to hold insulin dose
 - Rebound hyperglycemia

DUHS Goals for Inpatient Diabetes Management

- A1c on admission for anyone with diabetes or elevated BG
 - D/C oral agents and divide mixed insulins
 - 4 shot insulin regimen or IV insulin infusion
 - Ideally - Basal/Bolus insulin with rapid acting insulin and long acting insulin
 - Acceptable - Regular ac and NPH qhs
 - Target BGs < 110 mg/dl critical care areas and FBG < 110 mg/dl with post meal < 180 mg/dl
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Resources

- Diabetes Management Service (6533)
 - Melanie Mabrey (970-4168)
 - Diabetes Education
 - “Getting Started with Diabetes” order from pharmacy
 - Channel 36 - all diabetes, all the time
 - Certified Diabetes Educator – Ellen Davis (970-6072)
 - Nutrition Consult
 - Referral for outpatient Diabetes Education
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Discharge and Transition

- Use the hospitalization as a “Window of Opportunity”
- Opportunity –
 - Change in regimen
 - If it is good in the hospital then it must be good...
 - Validation of outpatient provider
 - “Someone else is saying the same thing my PCP said.”
 - Fear factor
 - “Oh goodness! Now I’m ready to make a change.”
- Evaluate patient’s ability, willingness, and appropriateness for use of an intensive insulin regimen (or any other diabetes regimen)
- Provide tools and resources necessary for effective follow-up