

Diabetes Management at BJH Review of Inpatient Management

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Discolsure

- Grant: Cystic Fibrosis Foundation EnVision Grant for Endocrine clinical care and research in the field of Cystic Fibrosis, 2016-2019
- I have no conflicts for today's talk

Goal

“To provide hospital providers with expert perspectives on current best evidence and treatment guidelines with a focus on achieving specific glycemic targets in a safely”



Learning Objectives

- To review criteria for the diagnoses of diabetes
- To understand epidemiology of DM
- To discuss the effects of diabetes on micro/macrovacular complications, and on inpatient morbidity/mortality
- To discuss the cost associated with inpatient care
- To apply clinical practice guidelines and current evidence to improve inpatient management of patients with DM
- To implement practices in the management of hypo and hyperglycemia in the hospitalized patient
- To review new insulin therapies and diabetes technologies you may run across in a hospitalized patient
- To identify the types of errors in inpatient medication/ins administration

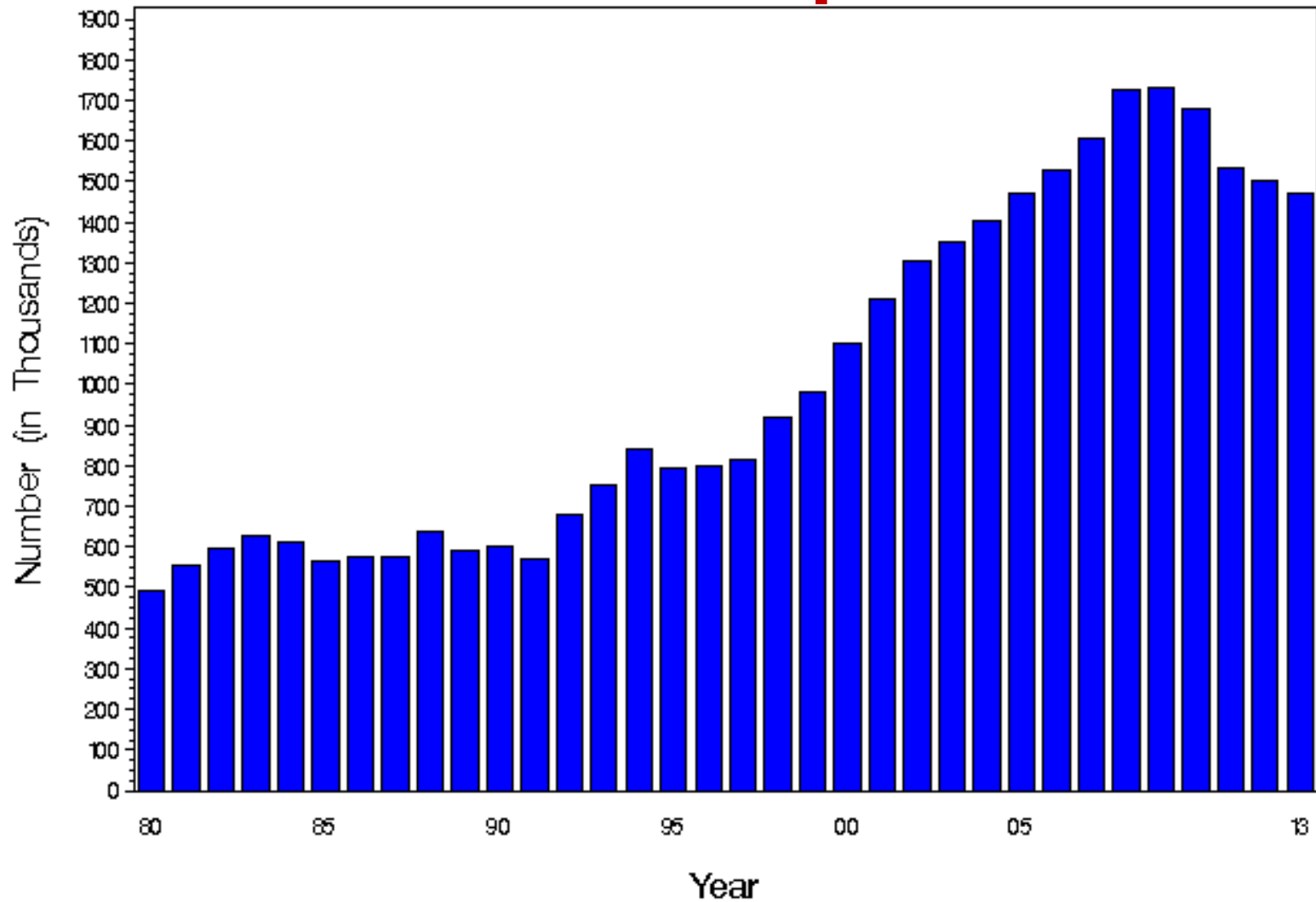


Diagnostic Criteria for Diabetes

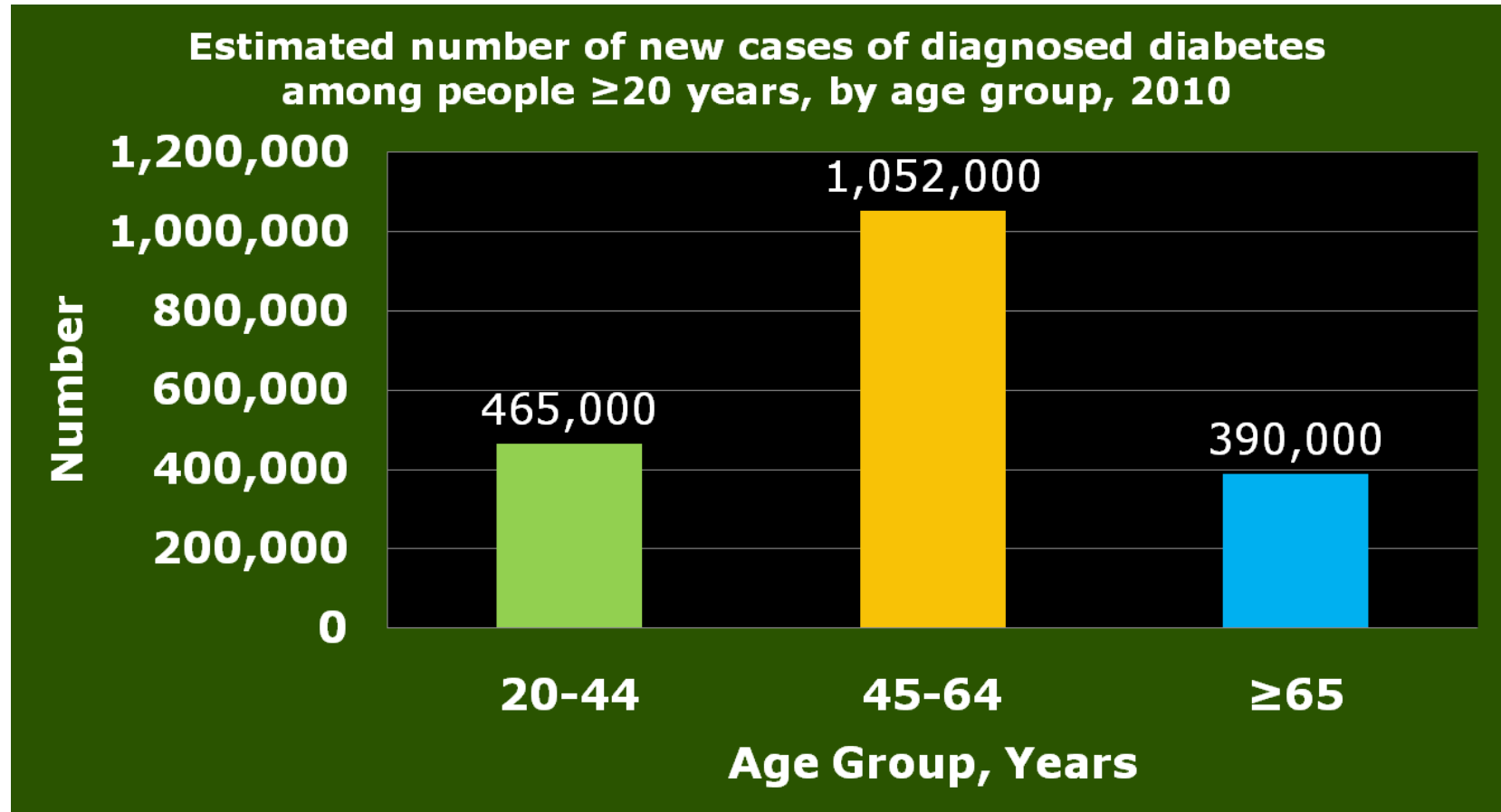
- **Requires ONE of the following:**
 - ✓ A1C \geq 6.5%
 - ✓ Fasting glucose \geq 126
 - ✓ Two-hour plasma glucose post 75 gram glucose load, \geq 200
 - ✓ Classic symptoms of hyperglycemia with glucose \geq 200
- **Confirm results with repeat testing (unless unequivocal hyperglycemia)**

EPIDEMIOLOGY

Diabetes – An Epidemic

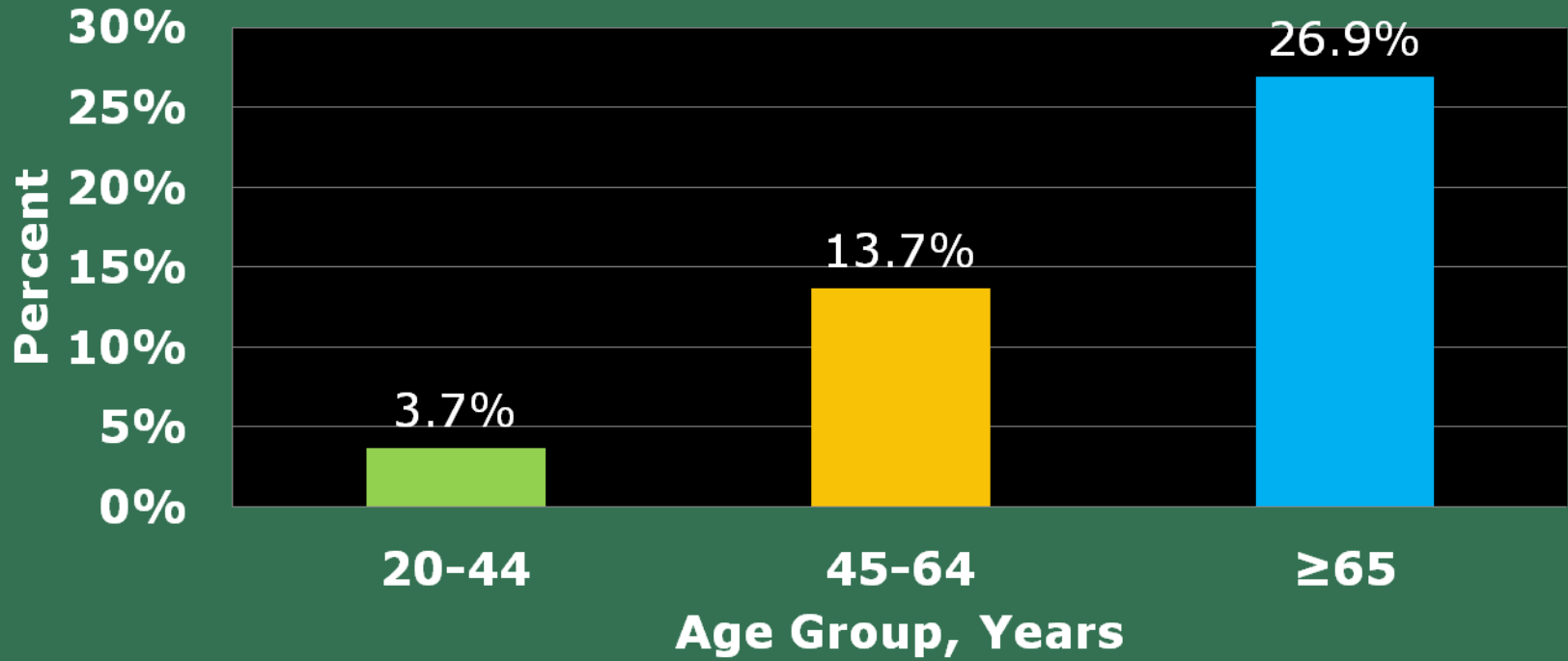


New Cases of Diagnosed Diabetes



Diabetes Prevalence Increases with Age

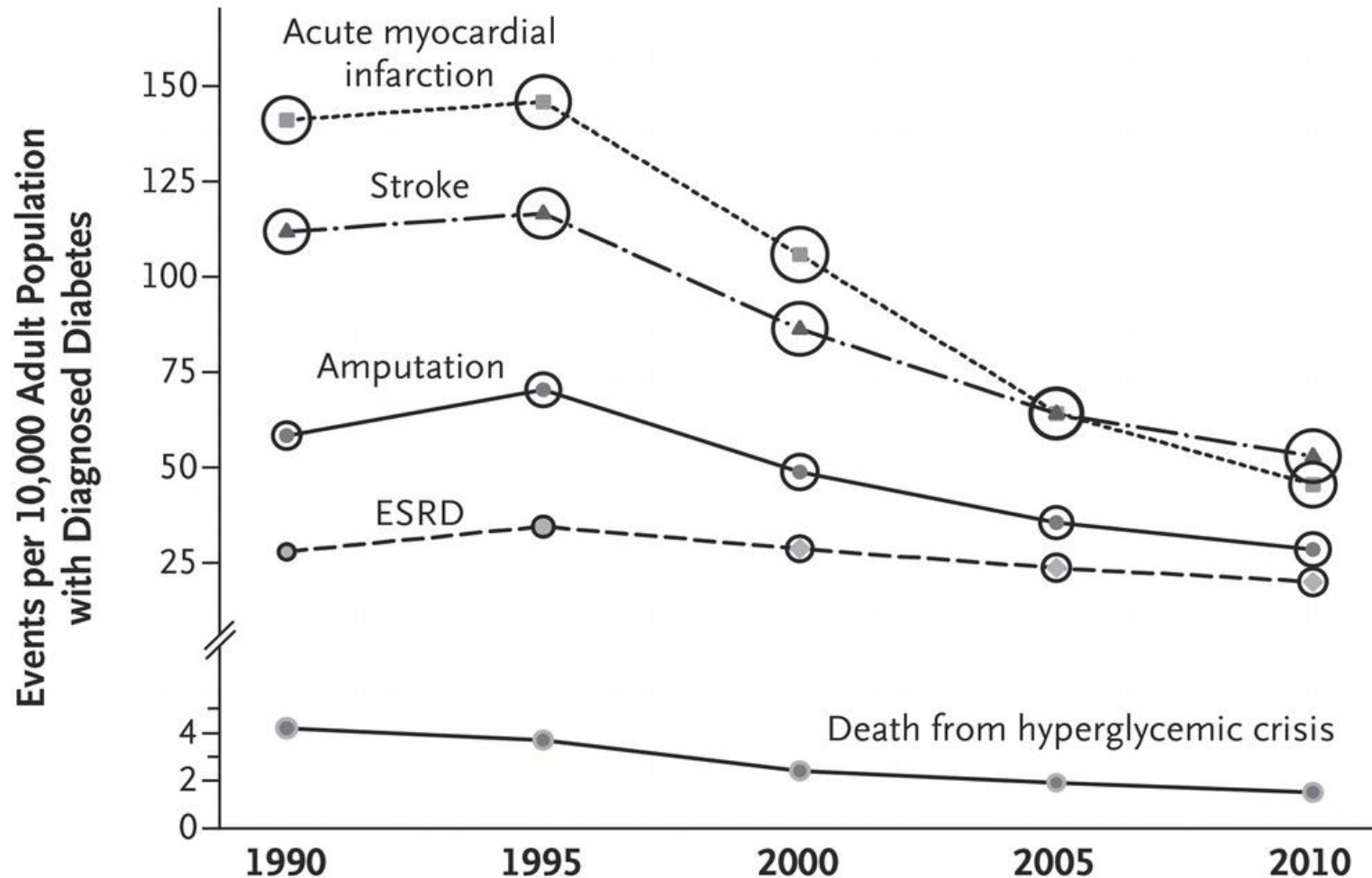
Estimated percentage of people ages ≥ 20 years with diagnosed and undiagnosed diabetes, by age group, United States, 2005-2008



Source: 2005-2008 National Health and Nutrition Examination Survey estimates projected to the year 2010

Diabetes-Related Complications among U.S. Adults: 1990–2010.

A Population with Diabetes

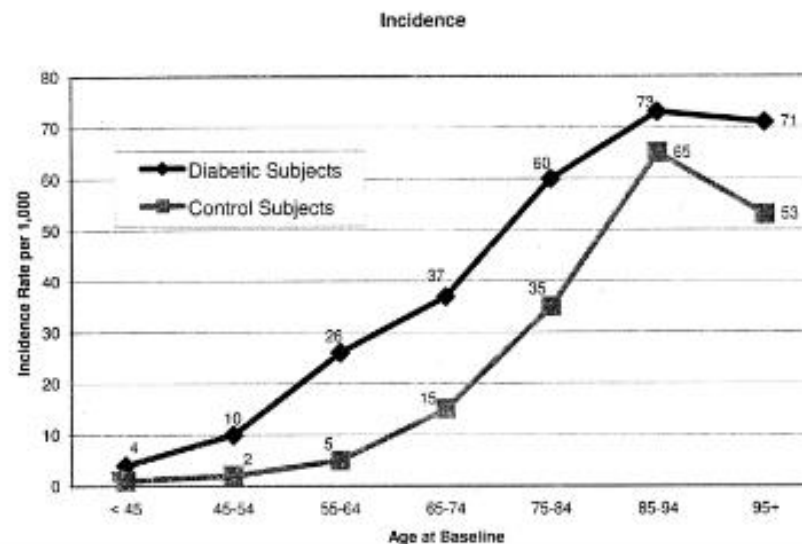
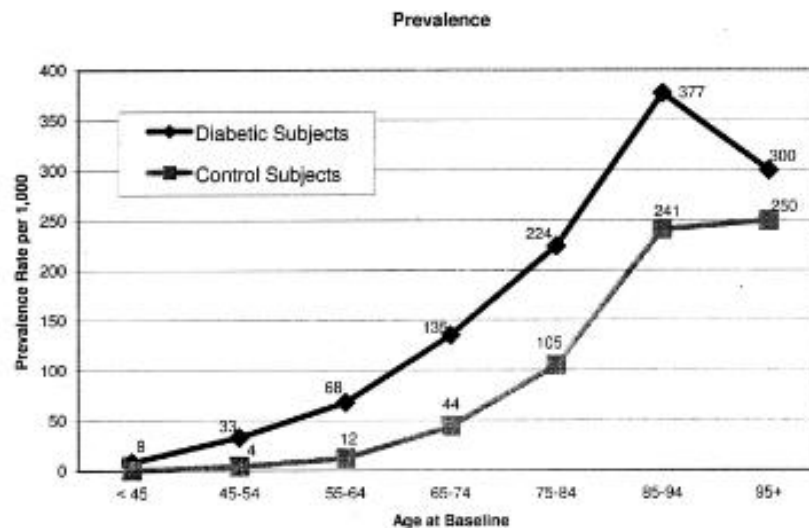


Complications of Diabetes: Hypertension - Heart Disease - Stroke

- In 2005-2008, of adults ages ≥ 20 years with self-reported diabetes, **67%** had blood pressure $\geq 140/90$ mmHg or used prescription medications for hypertension
- In 2004, of diabetes-related death certificates among people ages ≥ 65 years, **68%** noted heart disease and **16%, stroke**
 - Adults with diabetes have heart disease death rates ~2–4 times higher than those without DM
 - Stroke risk is 2–4 times higher

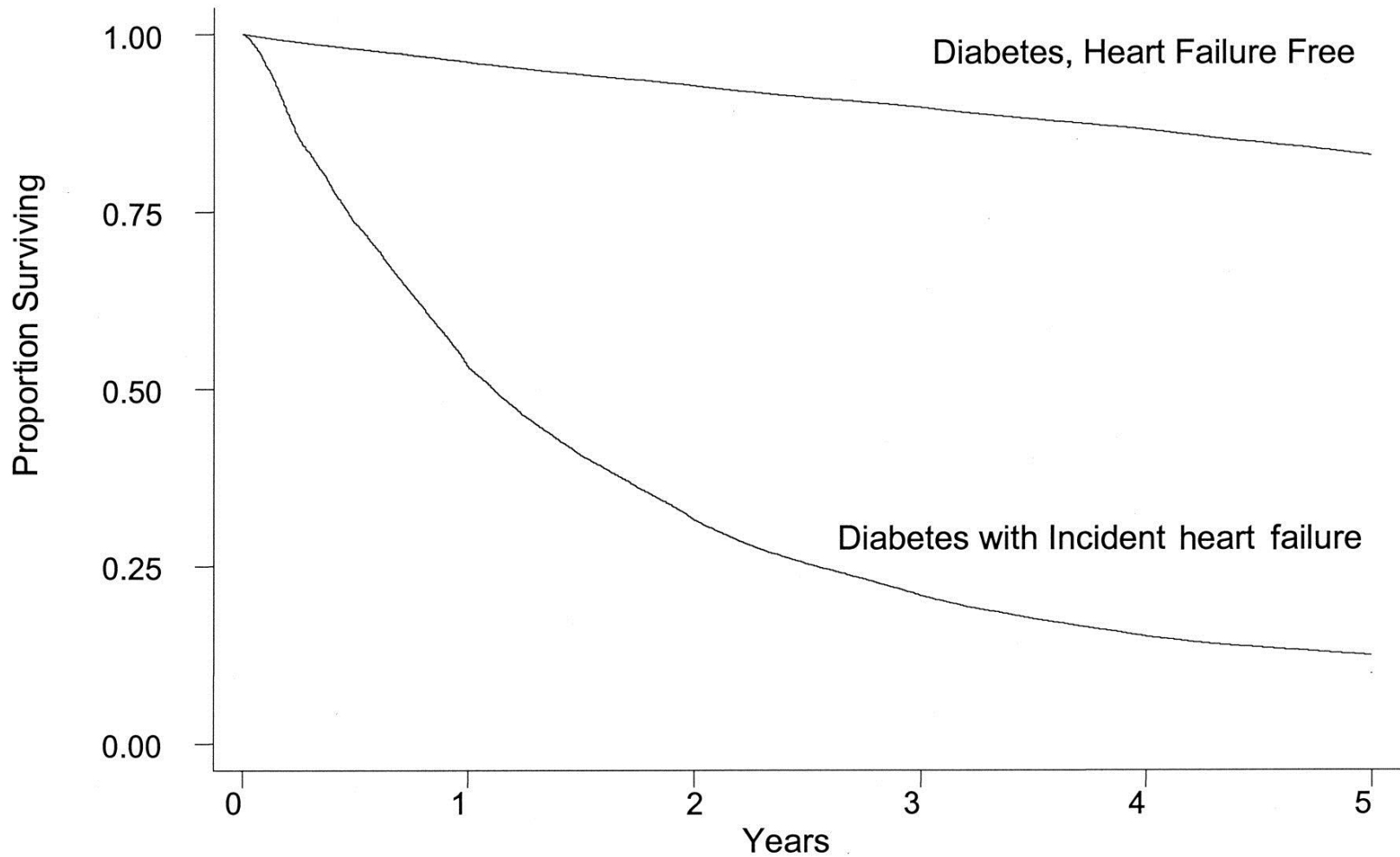


Heart Failure and Diabetes



Five-year Kaplan-Meier survival estimates

Patients ≥ 65 years old with HF



Link Between Hyperglycemia and Morbidity

Long term: (DCCT, EDICT, UKPDS)

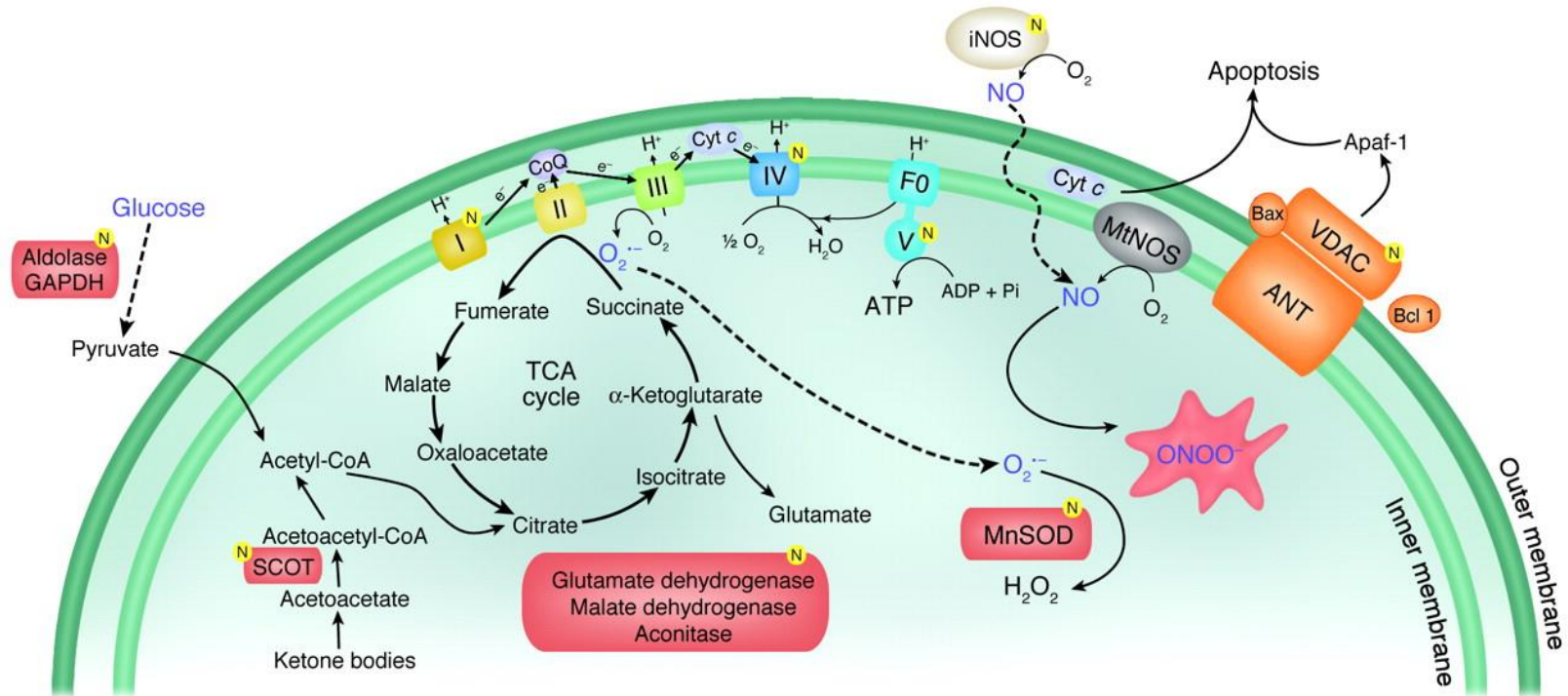
- Microangiopathy
- Macroangiopathy

Short term:

- Cellular
- Immune
- Thrombolytic system



Glucose Toxicity



Effect of Hyperglycemia on Brain and Cardiac Tissues

- **Impairs ischemic preconditioning**
- **Increases infarct size**
- **Promotes apoptosis**
- **Acute hyperglycemia increases blood pressure, catecholamines**
- **Increased tissue lactate and glutamate levels**



Marfella, Diabetes Care 23:2000

Slide courtesy of Drs. Tobin and Fisher

Economic Costs of Diabetes 2012

Total cost of diabetes: \$275 billion (176 billion in direct costs, and 69 billion in reduced productivity)

- **Hospital inpatient care (43%)**- This is the largest cost of DM care.
- Diabetes medication and supplies (12%)
- Retail prescriptions to treat complications of diabetes (18%)
- Physician office visits (9%)

Focusing on **preventing readmissions** can help **improve outcomes** and reduce incurred **cost**.

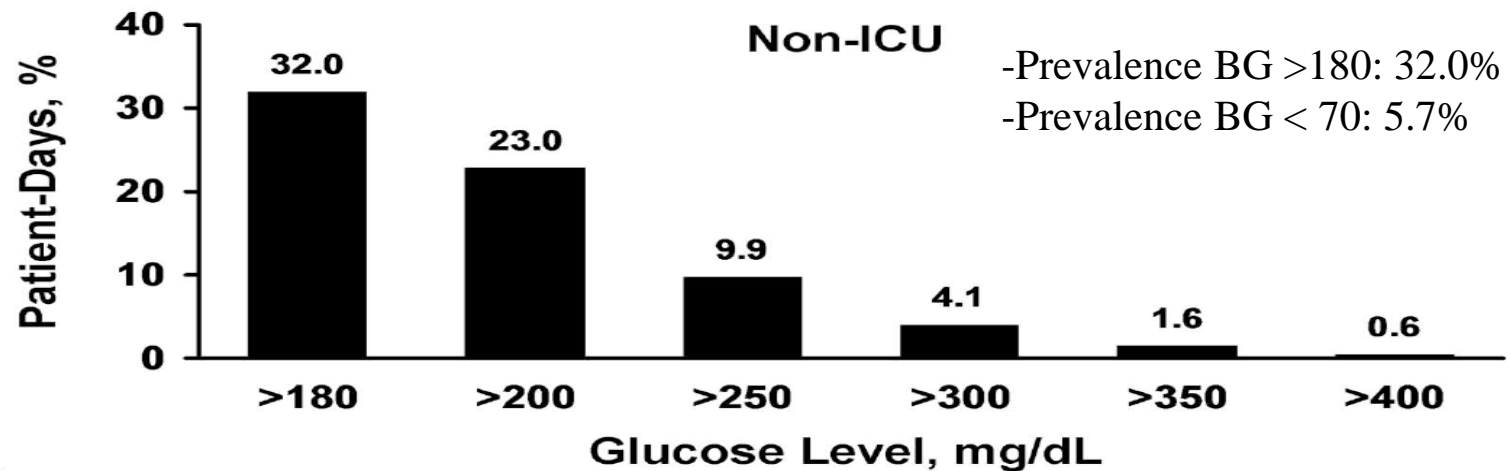
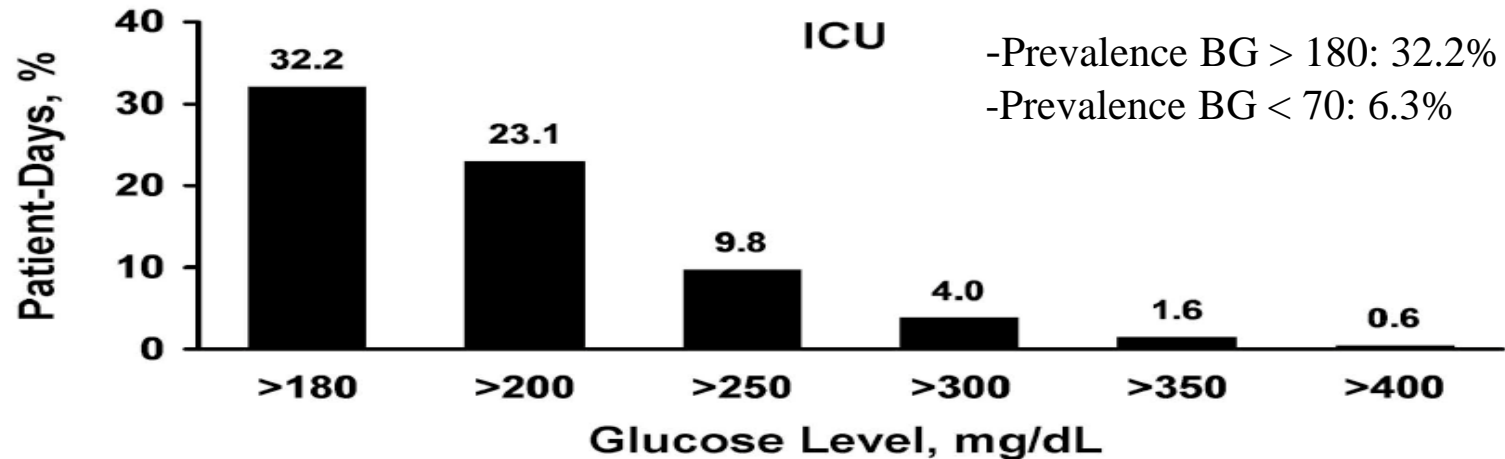
Focusing on **safe treatment** in the hospital can improve outcomes and likely decrease readmissions.

Inpatient Hyperglycemia: Prevalence, and Effects on Clinical Outcomes



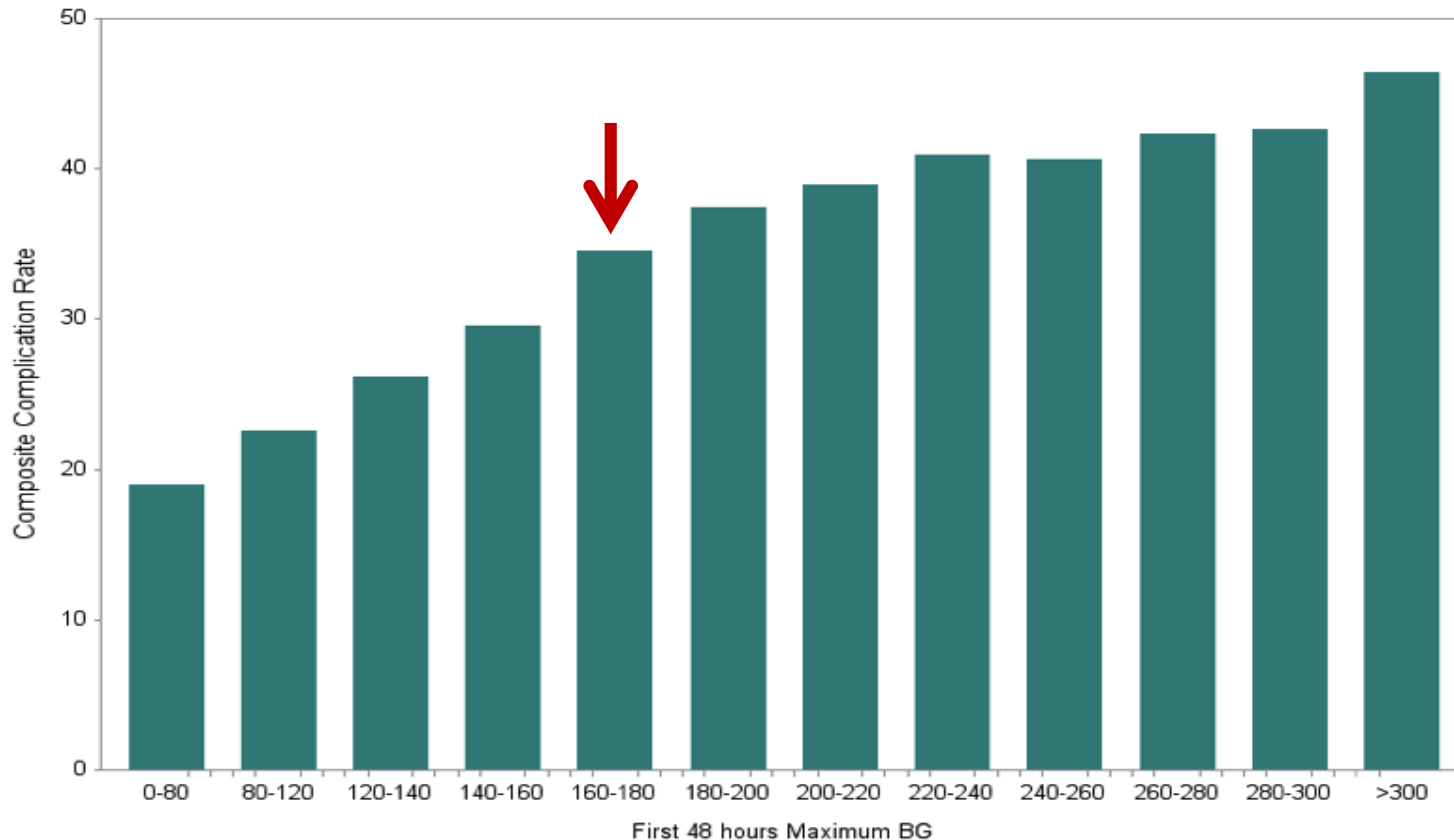
"The 'Humungo Meal' comes with your choice of 2 sides...heart disease, high blood pressure, diabetes or obesity."

Prevalence of Inpatient Hyperglycemia



What Glucose Level Predicts Hospital Complications?

Composite Complication Rate by Maximum BG Level



2X ↑ BG
>300

N= 55,530 patients records in ICU and non-ICU, Emory University Hospitals.

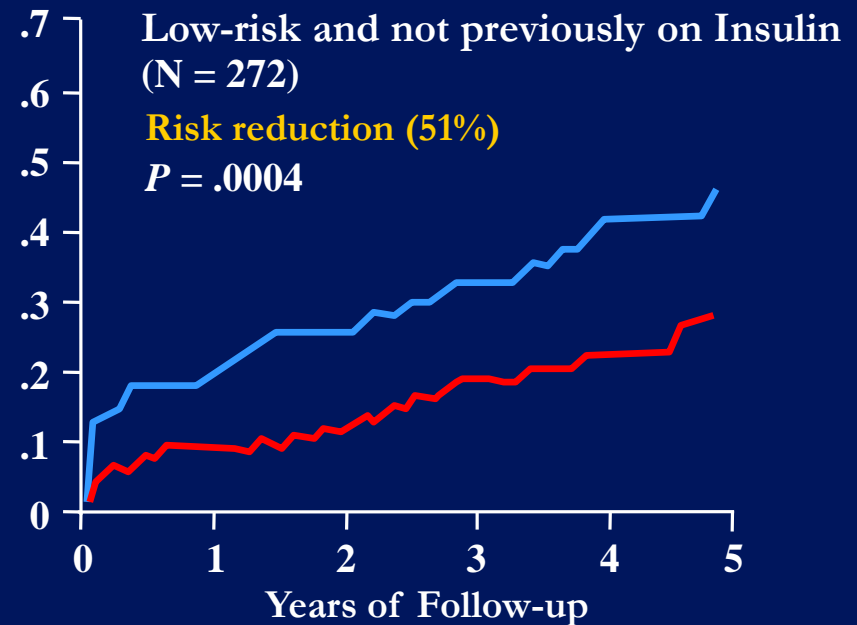
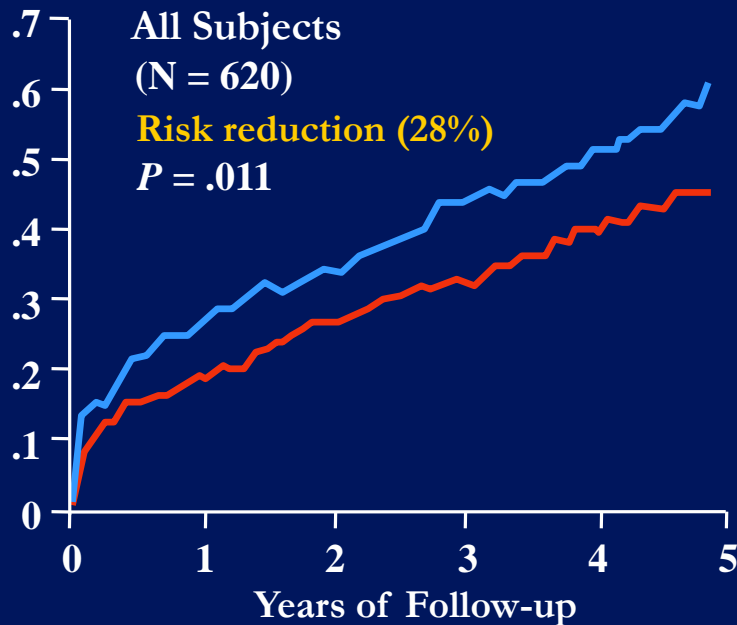
Composite of complications: pneumonia, acute renal or respiratory failure, acute MI, bacteremia, and death.

DIGAMI Study

Mortality After MI Reduced by Insulin Therapy

— Standard treatment

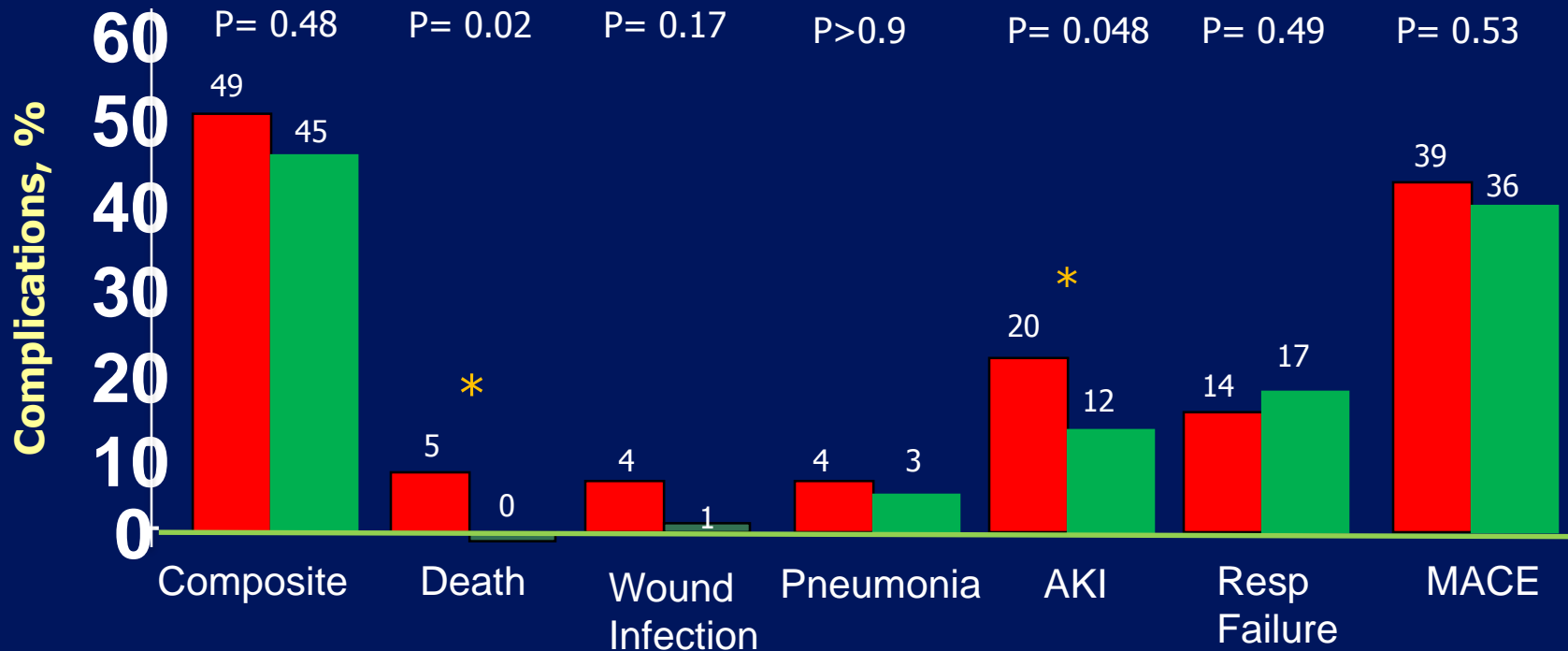
— IV Insulin 48 hours, then 4 injections daily



et al. *BMI*. 1997;314:1512-1515

Perioperative Complications - CABG: DM vs no-DM

■ Diabetes ■ No-Diabetes

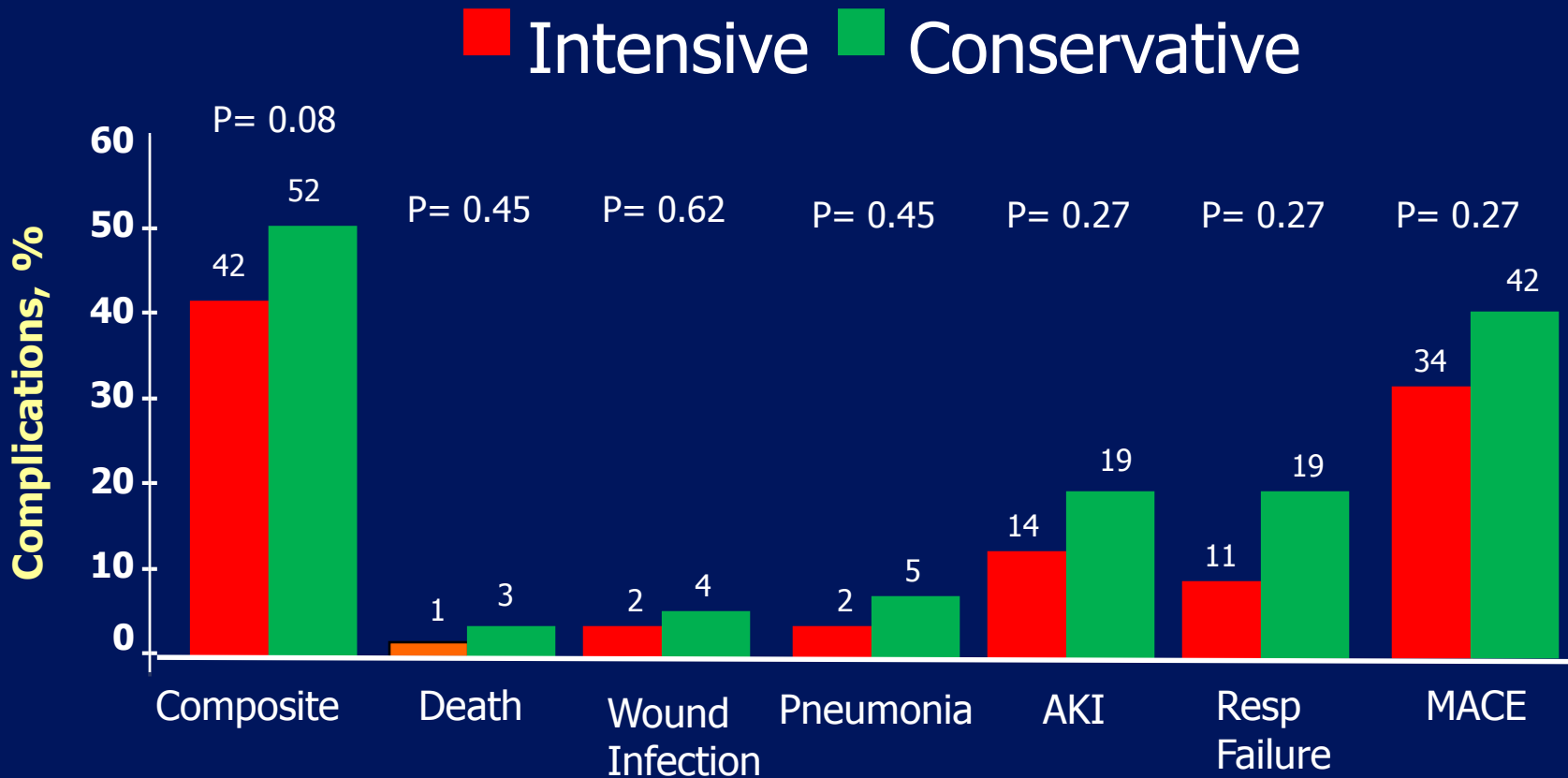


Data are means \pm SEM

Composite of complications: death, wound infection, pneumonia, acute kidney injury (AKI), respiratory failure, and major cardiovascular events (MACE)

Umpierrez GE, et al. 2014 ADA Scientific Meeting; Slide courtesy of Drs. Dungan and Umpierrez

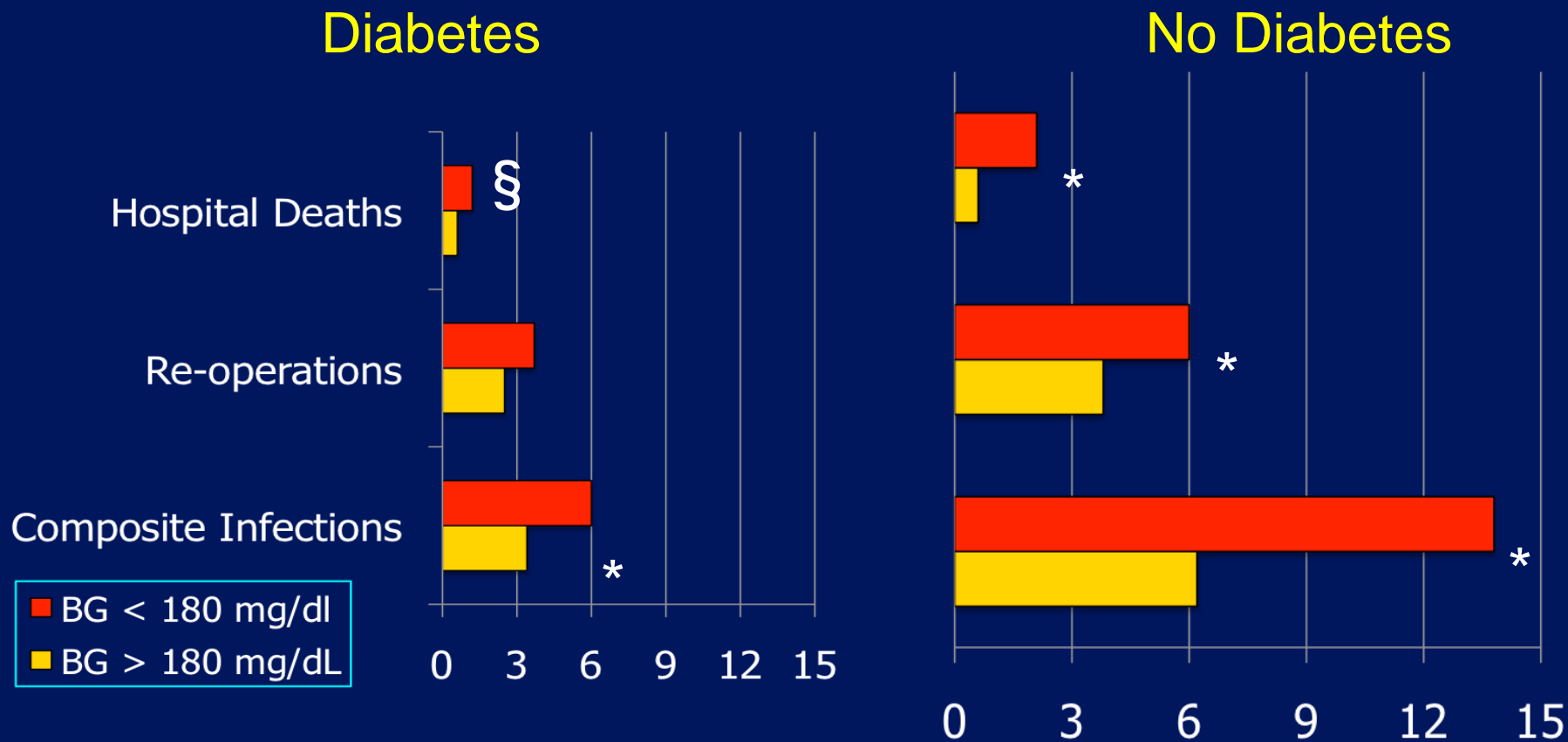
Perioperative Complications



Data are means \pm SEM

Composite of complications: death, wound infection, pneumonia, acute kidney injury (AKI), respiratory failure, and major cardiovascular events (MACE)

Adverse Events Stratified by Perioperative Hyperglycemia



* P < 0.01

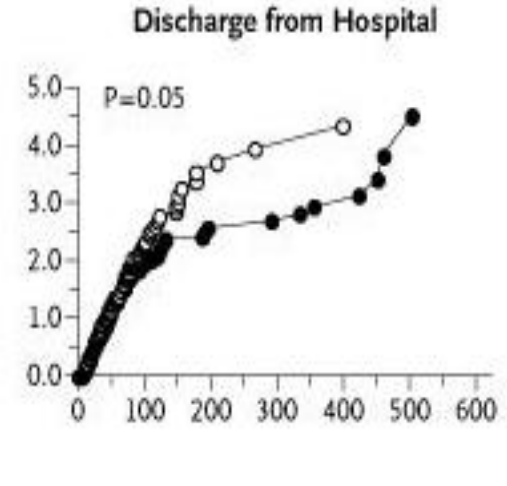
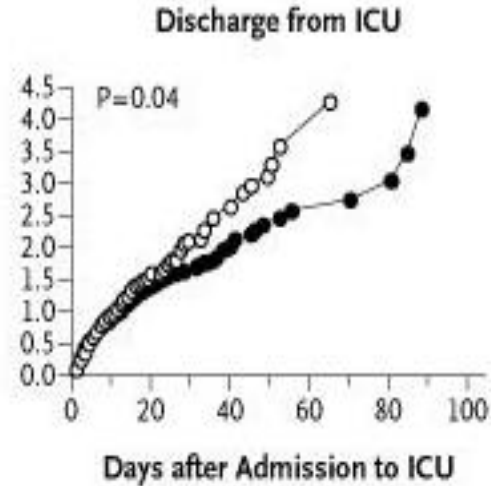
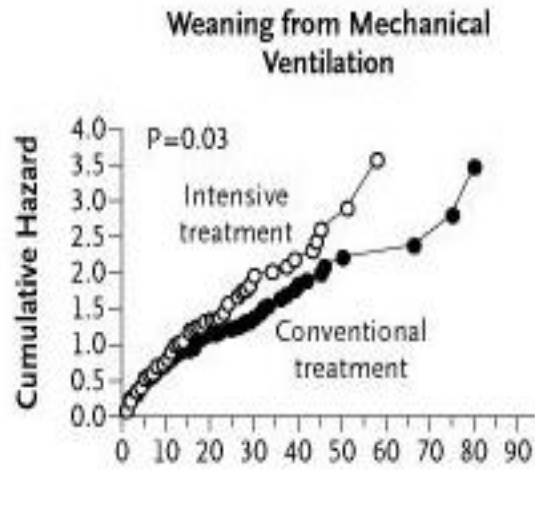
§ p < 0.05

Proportion of Patients (%)

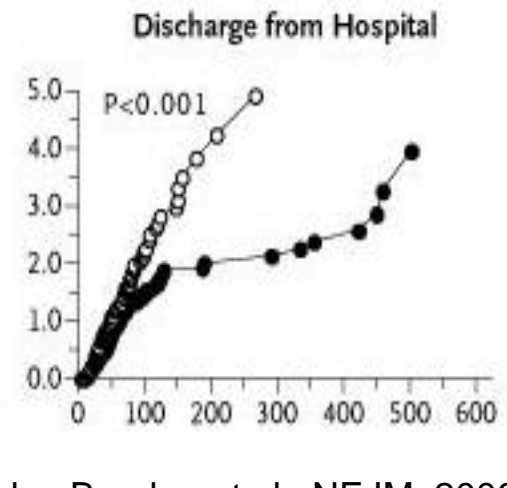
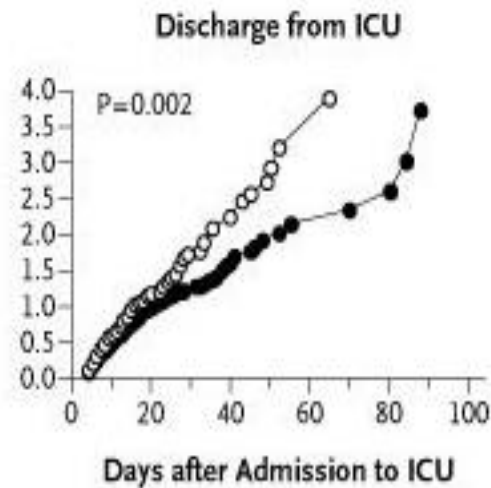
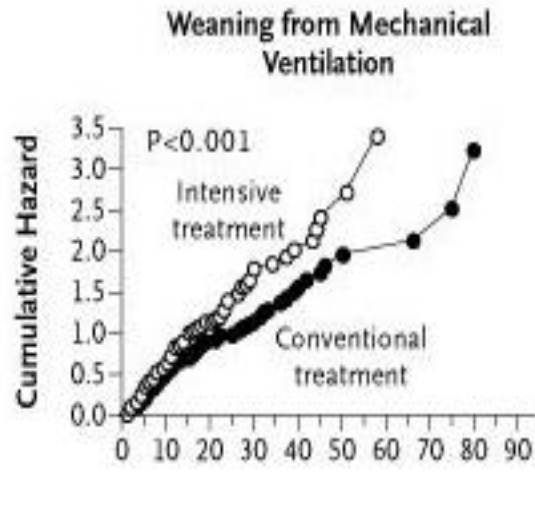
BG at any point on the day of surgery, post-op day 1 and 2
 N= 11,633, colorectal and bariatric surgery;
 29.1% with hyperglycemia

Intensive Insulin Therapy in the Medical ICU

A



B



ICU Hyperglycemia: Intensive Glucose Control

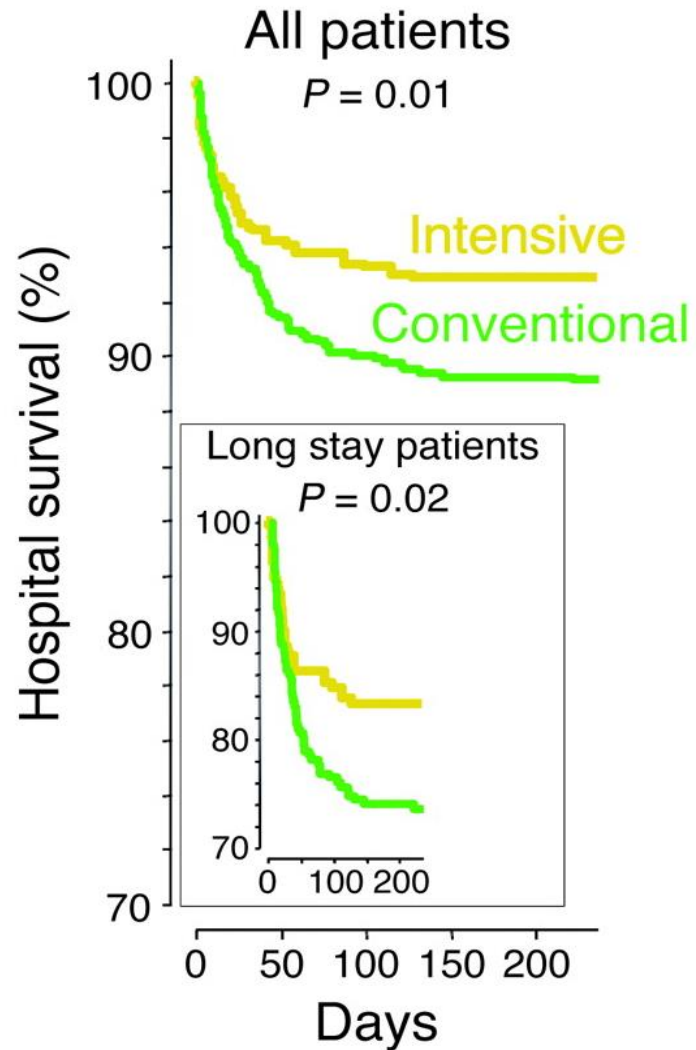
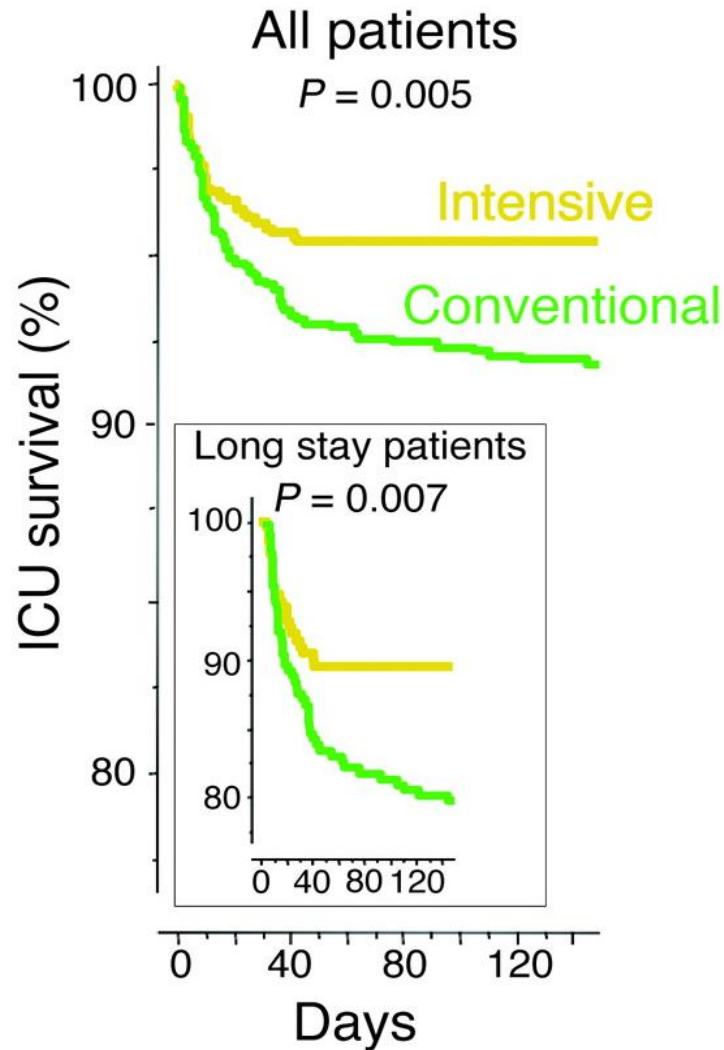
Clinical Trials in Medical and Surgical ICU Patients

Trial	N	Setting	Primary Outcome	ARR	RRR	Odds Ratio (95% CI)	P-value
Van den Berghe 2006	1200	MICU	Hospital mortality	2.7%	7.0%	0.94* (0.84-1.06)	N.S.
Glucontrol 2007	1101	ICU	ICU mortality	-1.5%	-10%	1.10* (0.84-1.44)	N.S.
Ghandi 2007	399	OR	Composite	2%	4.3%	1.0* (0.8-1.2)	N.S.
WISEP 2008	537	ICU	28-d mortality	1.3%	5.0%	0.89* (0.58-1.38)	N.S.
De La Rosa 2008	504	SICU MICU	28-d mortality	-4.2% *	-13%*	NR	N.S.
NICE-SUGAR 2009	6104	ICU	3-mo mortality	-2.6%	-10.6	1.14 (1.02-1.28)	< 0.05

* not significant

ITT trials also associated with increased rates of hypoglycemia

Intensive Insulin Therapy SICU Survival



Insulin Studies in Surgical Patients

Protocol	N	% DM	Hypo	IIT BG target	Control BG target	Outcome
Furnary	2467	100	NR	150-200	Historic control	↓ ICU/Hospital mortality and complications
Leuven	1500	13	5.1	80-110	180-200	↓ ICU/ hospital mortality and complications
Okabayasi	502	25	0	80-110	140-180	↓ Surgical Site Infections
Rabbit-Surgery*	211	100	4	<140	<140	↓ Hospital complications
GLUCO-CABG	302	50	0	100-140	141-180	No difference in mortality or hospital complications

Hypo = Hypoglycemia (< 40 mg/dl)

* Non-ICU trial – basal bolus vs SSI in general surgery

1. Furnary AP, et al. *Ann Thorac Surg.* 1999;67:352–362

2. Van Den Berghe G, et al. *N Engl J Med.* 2001;345:1359; 2. Van Den Berghe G, et al. *N Engl J Med.* 2006;354:449-461;

3. Okabayasi et al. *Diabetes Care* 2014

4. GLUCO-CABG- Umpierrez et al, ADA and Endo Society meeting (Unpublished)

Management of Inpatient Diabetes



Inpatient Glycemic Control: Targets

- Target glucose levels: Pre meal < 140, Random or post meal < 180 mg/dL
- The safe low glucose target in hospital is 90-100 mg/dL
- ICU generally 130-150 mg/ dL
- Hospital safety metrics and surveillance for blood sugars < 40 and > 299 mg/dL
- We need to strive for **targeted control** on patients we are treating; TEACH BY EXAMPLE.



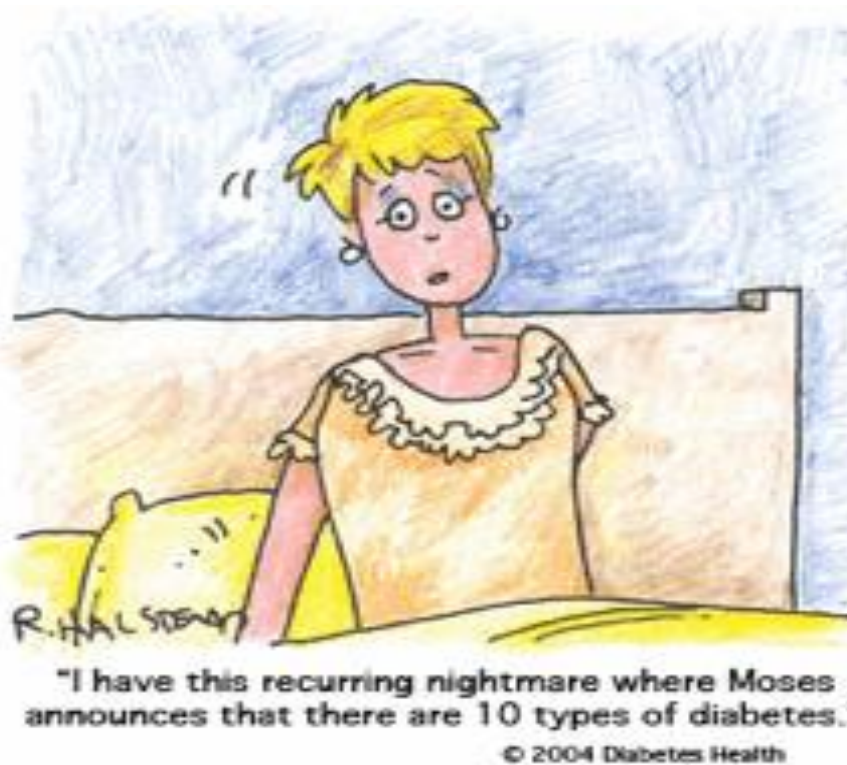
Inpatient Diabetes History

- What type of Diabetes does the patient have?
- Prior therapies and response
- Previous A1c (obtain if none in the last 3 months).
- Weight in last 3-6 months
- Monitoring – frequency and timing
- Presence of **hypoglycemia** – frequency and timing
- Prior education- Who and where did pump training occur?
- Additional elements related to ability to follow through and social issues including costs.
- Blood glucose at home and in hospital



Slide Courtesy of Dr. Tobin

Classification of Diabetes



Prevalence of Type 2 diabetes in population age 10-19 years has increased. Non-Hispanic Blacks rate of 32 / 100, 000 versus Non-Hispanic white 3/ 100,000. Overall rate is about 11%.

Consider ordering C peptide to stratify risk

Odd family HX – consider genetic screening - Dr. Lou Phillipson _ Univ. Chicago

Search for Diabetes in youth study

Diagnosis & Recognition of Hyperglycemia and Diabetes in the Hospital Setting

Admission

Assess all patients for a history of diabetes

Obtain laboratory BG testing on admission

No history of diabetes
BG < 140 mg/dl
(7.8 mmol/L)

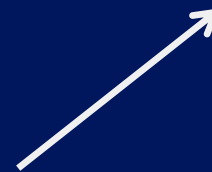
Initiate POC BG
monitoring according
to clinical status

No history of diabetes
BG > 140 mg/dl or high risk
(major surgery, TPN,
steroids) for
hyperglycemia

Start POC
BG monitoring x 24-48h
Check A1C, if $\geq 6.5\%$

History of DM

BG monitoring



Management of Inpatient Diabetes

Antihyperglycemic Therapy

Insulin

Recommended

OADs

Not Generally
Recommended

IV Insulin

Critically ill
patients in the
ICU

SC Insulin

Non-critically ill
patients

Non-Insulin Injectables

Not Generally
Recommended

Oral Antidiabetic Medications

DRUG

CONSIDERATIONS

Sulfonylureas

Hypoglycemia

Metformin

Renal and lactic acidosis

TZDs

Delayed action, edema

SGLT-2 inhibitor

Glycosuria, infections

GLP1-RA

DPP-4 inhibitors

**May be useful for
hospital use**

Slide courtesy of Dr. Umpierrez

Reasons for Deterioration of Glycemic Control During Hospitalization

Hyperglycemic Influences

- “Stress” hyperglycemia
- Decreased physical activity
- Medication omissions
- Medication errors-Insulin
- Fear of hypoglycemia
- Dietary indiscretion
- Glucocorticoid use
- TPN/tube feeds/IV dextrose

Hypoglycemic Influences

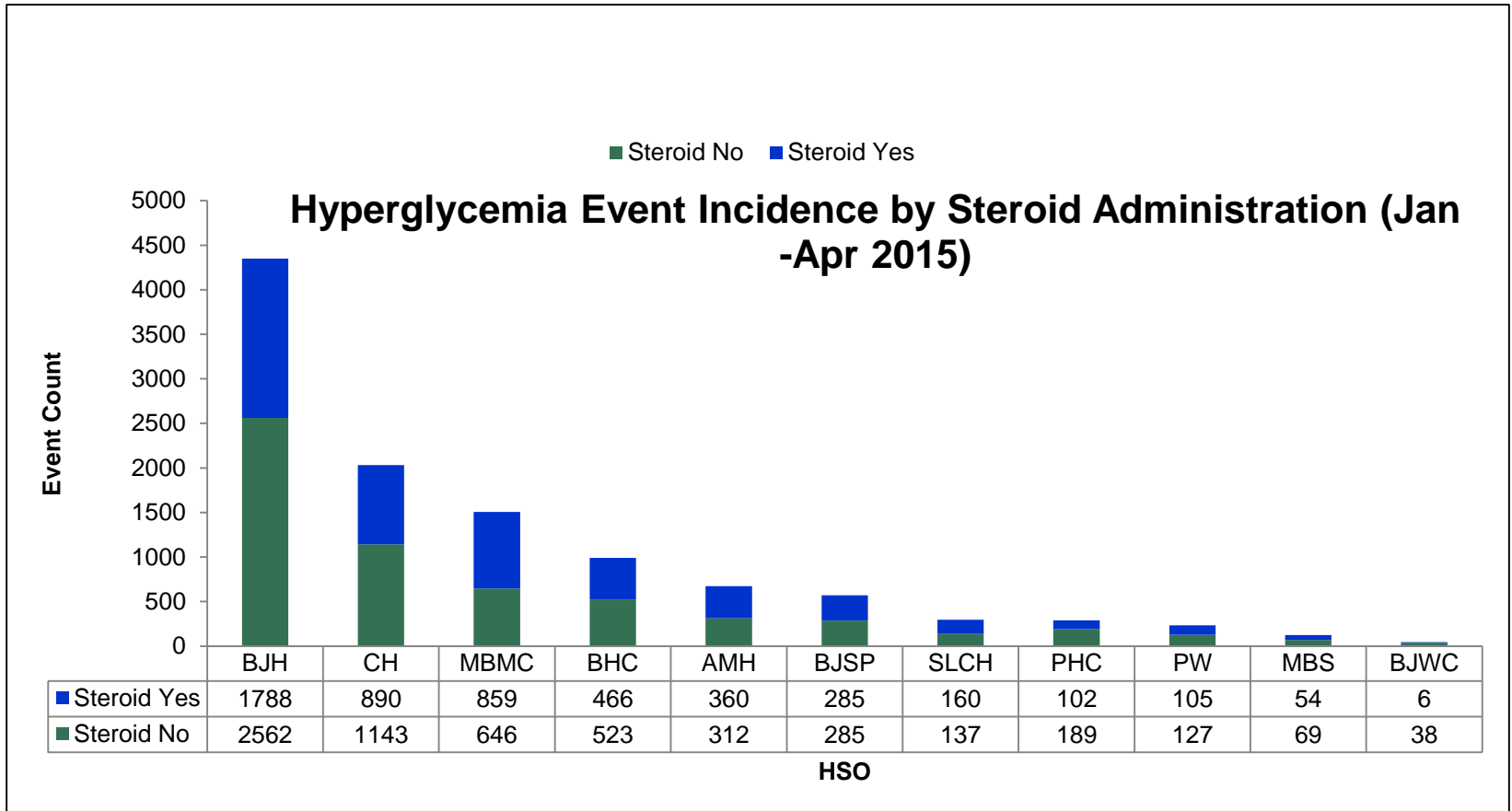
- Decreased caloric intake
- NPO
- Gastrointestinal illness
- Monitored compliance
- Medication errors-Insulin
- Altered cognition
- Glucocorticoid wean
- Change in renal function

Other Factors Affecting Blood Glucose Levels in the Hospital Setting

- Increased counter-regulatory hormones
- Changing IV glucose rates
- TPN and enteral feedings
- Lack of physical activity
- Unusual timing of insulin injections
- Use of glucocorticoids/immunosuppressants
- Unpredictable or inconsistent food intake
- Octreotide use
- Cultural acceptance of hyperglycemia
- Patients administering own insulin or refusing scheduled insulin

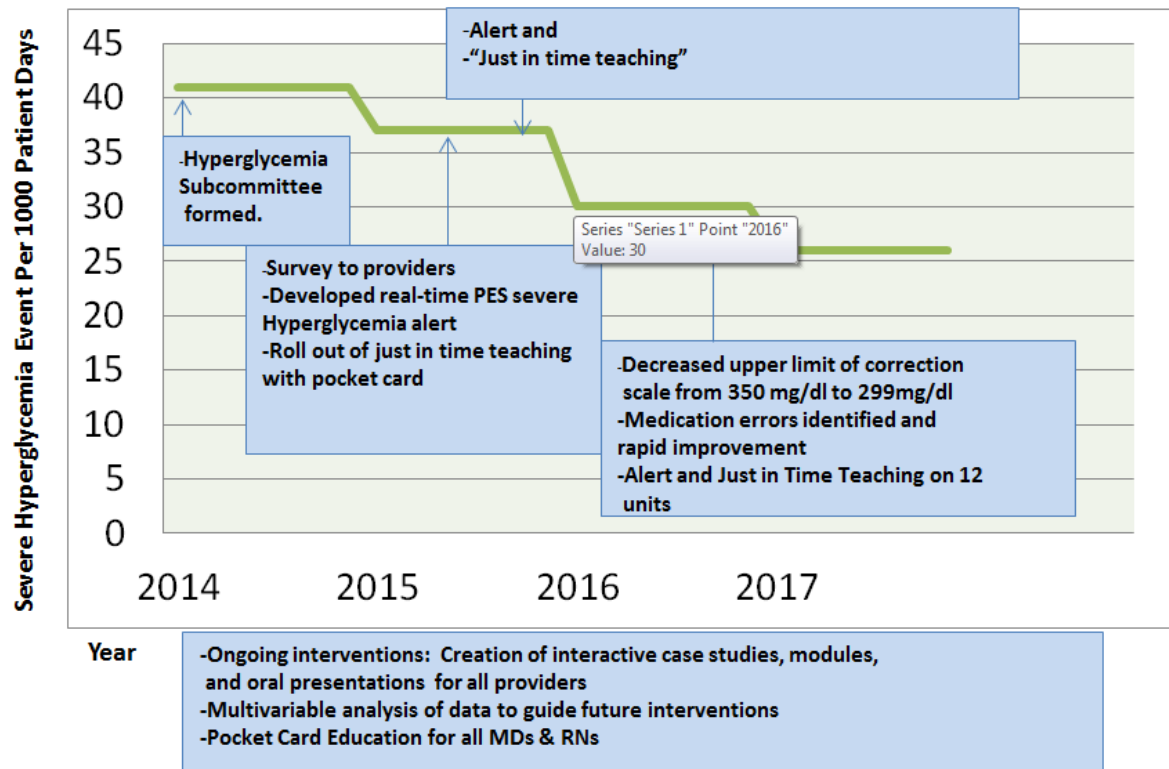


Hyperglycemia Events: Event Count by Steroid Administration January – April 2015



HYPERGLYCEMIA RATES BJH

Severe Hyperglycemia QI Interventions



Hyperglycemia prevention

Structured order sets and sliding scales

We are in the process of setting up a control room surveillance system for glycemic control

Educational modules

We are in the process of developing a predictive steroid alert

Protocols for steroids

Standardization of insulin therapy in Surgery and for tube feeds

Inpatient Insulin Administration



Potential Beneficial Effects of Insulin

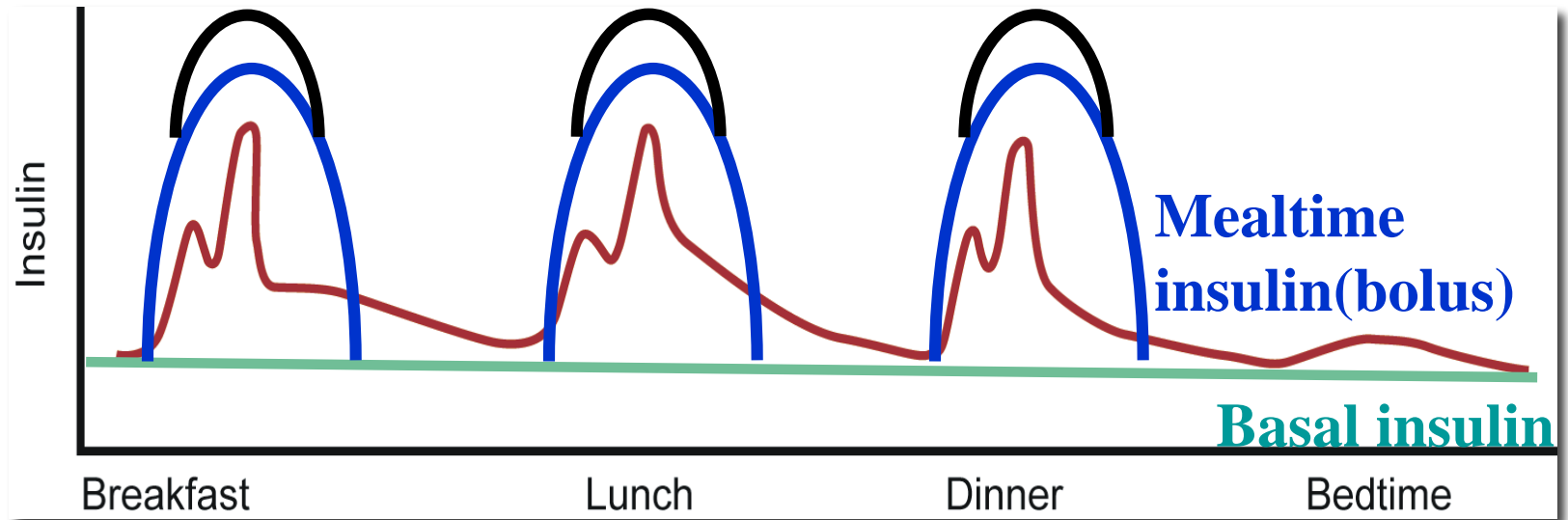
- **Suppresses free fatty acid production**
- **Enhances NO production in intact endothelium**
- **Inhibition of pro-inflammatory cytokines**
- **Suppression of inflammatory growth factors**
- **Insulin, probably through its effect on cytokines, normalizes PA1 levels and acute inflammatory response**

Components of Insulin Therapy

- **Basal insulin:** the amount of insulin necessary to regulate glucose levels between meals and overnight
 - Detemir (Levemir), glargine (Lantus), NPH, etc
- **Nutritional insulin:** **insulin** required to cover meals, IV dextrose, enteral nutrition, total parenteral nutrition (TPN), or other nutritional supplements
 - Rapid-acting: aspart (NovoLog), glulisine (Apidra), lispro (Humalog)
 - Short-acting: regular (Humulin, Novolin)
- **Correction insulin:** supplemental doses of short- or rapid-acting insulin given to correct blood glucose elevations that occur despite use of basal and nutritional insulin. Usually administered before meals together with nutritional insulin

Maintaining Physiologic Insulin Delivery in the Hospital

Supplemental or “stress”
insulin (correction)



Moghissi ES, Korytkowski MT, DiNardo M, et al. American Association of Clinical Endocrinologists and American Diabetes Association consensus statement on inpatient glycemic control. *Endocr Pract.* 2009;15:353-69.

Umpierrez GE, Hellman R, Korytkowski MT, et al. Management of hyperglycemia in hospitalized patients in non-critical care setting: an Endocrine Society Clinical Practice Guideline. *J Clin Endocrinol Metab.* 2012;97:16-38.

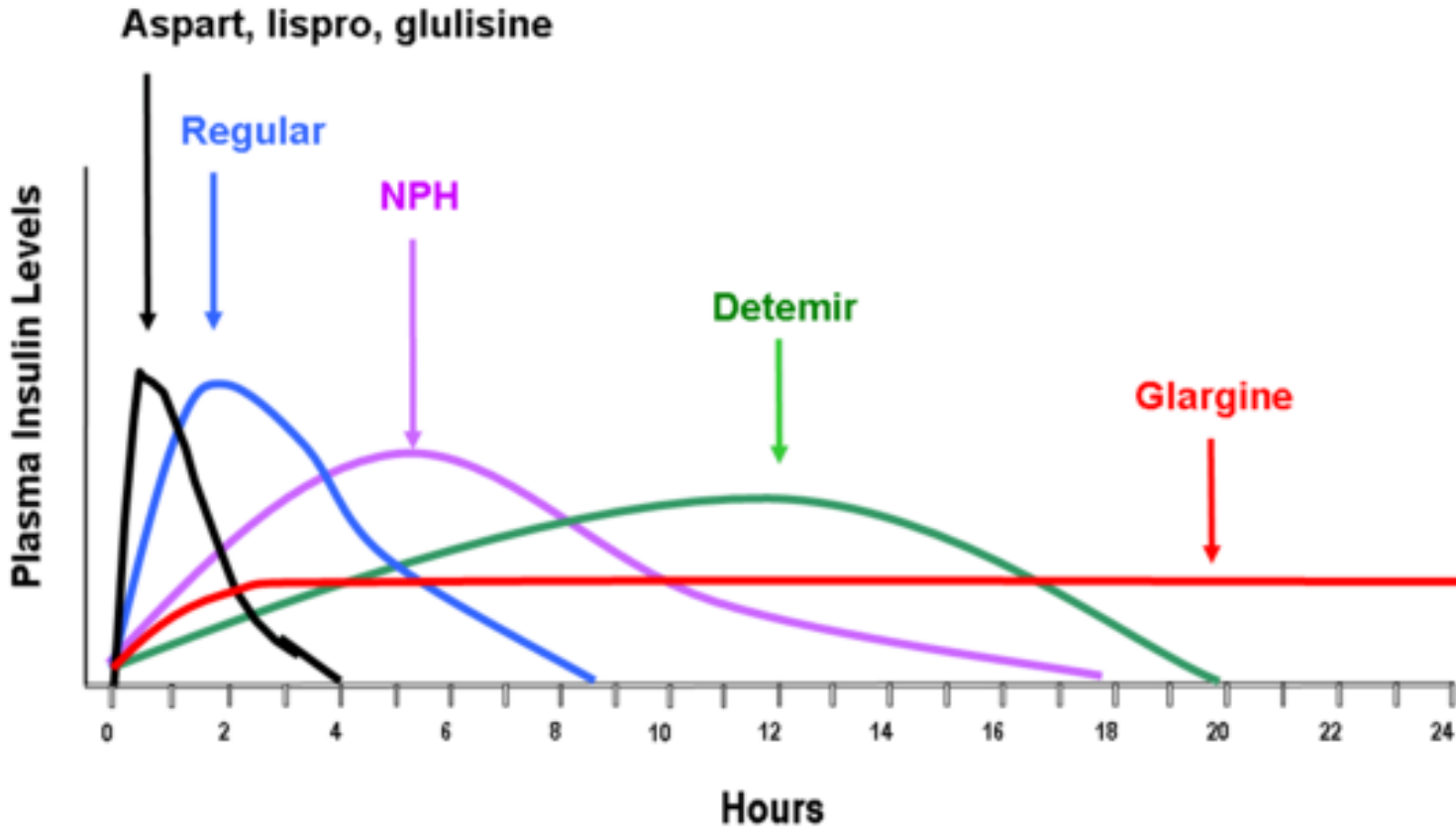
Point of Care Glucose Testing and Insulin Administration

- Proper timing of glucose testing and insulin administration can reduce the risk of hypoglycemia and hyperglycemia
- Administer short-acting regular insulin 30 min before meals
 - Regular insulin peaks in 2-4 hours
- Administer rapid-acting insulin analog 15 min before meals
 - Rapid-acting insulin analogs peak in 60-90 min

Pharmacokinetics of Insulin

	Onset	Peak	Duration
Aspart	<15 min	1 hr	3 hrs
Lispro	<15 min	1 hr	3 hrs
Glu-lysine*	<15 min	1 hr	3 hrs
Afrezza (inhaled)	<20 min?		
Regular	0.5–1 hr	2-3 hrs	3 – 8 hrs
NPH/Lente	2–4 hrs	6 –12 hrs	10-16 hrs
Glargine	1–2 hrs flat (?)		24 hrs
Degludec (u-2/300)			~36 hrs
Detemir*	1-2 hrs	8-12 (flat)	18-20 hrs
Mixed insulin 70/30; 75/25, 50/50, U -500			

Insulin Pharmacokinetics



General caveats about diabetic therapeutics and hospital policy- patient safety

Insulin pumps: Diabetes consult mandated by hospital.

U 200, U 300 insulin preparations are not on formulary as of yet. If patients come in on U 300 Glirgine-Toujeo or U 100, 200 Degludec-Tresiba call for assistance.

Type 1 Diabetes are high risk and should be seen by the Diabetes consult service.

U 500 humulin –Diabetes consult mandated by hospital.

NON STANDARD BASAL INSULIN

- *U 300 Glargine*- this is insulin Glargine concentrated and lasts up to 36 hours in clamp studies. The preparation gains its prolonged duration of action based on the micro-precipitation and a concentrated depot in the sub Q space. Dose titration generally Q 3 days. Their own clinical studies suggest that it requires 14% more in a head to head trial compared to U 100 Glargine but generally dose equivalency is 1:1.
- *Tresiba, Insulin Degludec* is a modified insulin analogue preparation that forms multi-hexamers in the sub q space which retards the absorption. It also has a fatty acid side chain that binds albumin further increasing its duration in the circulation. This is similar to Levemir in regard to the fatty acid side chain. The multi hexamer depot is unique to insulin Degludec. It has a duration of action that is estimated to be 42hour+ in clamp studies. The U 200 and U 100 preparations are bio-identical. This agent reaches steady state in 3-4 days and dose adjustments need to take this into account.



NON STANDARD BASAL INSULIN

COMPARE DOSE ESTIMATED ON WEIGHT COMPARED TO ACTUAL DOSE

Situation 1 – dose adjustment is not possible before procedure

- If estimated dose (ED) is < than current dose(CD) – This patient will need D5 to support blood sugars and close monitoring first 24 hours and no basal treatment unless clinically indicated. If basal is given, suggest NPH Q 8 hours to allow dose flexibility.
 - Call endocrine or pharmacy for guidance
- If estimated dose (ED) is > than current dose(CD)- This patient likely can be given an appropriate dose of Basal but will need to be cautious first 24 hours
- Dose basal insulin by 2nd and 3rd day formulary agent- Levemir, NPH, Glargine U 100

Situation 2- dose adjustment is possible before procedure starting 2 days prior to the procedure.

- Day -2: 50% of the basal of Tresiba or Toujeo
- Day- 1: 0-25% basal dosing of Tresiba or Toujeo
- Day 0: Day of procedure- no basal- monitor closely- Concern for Type 1 Diabetes- insulin drip or use NPH Q 8 hours 50% estimated basal
- Post op Standard MDI therapy with close monitoring

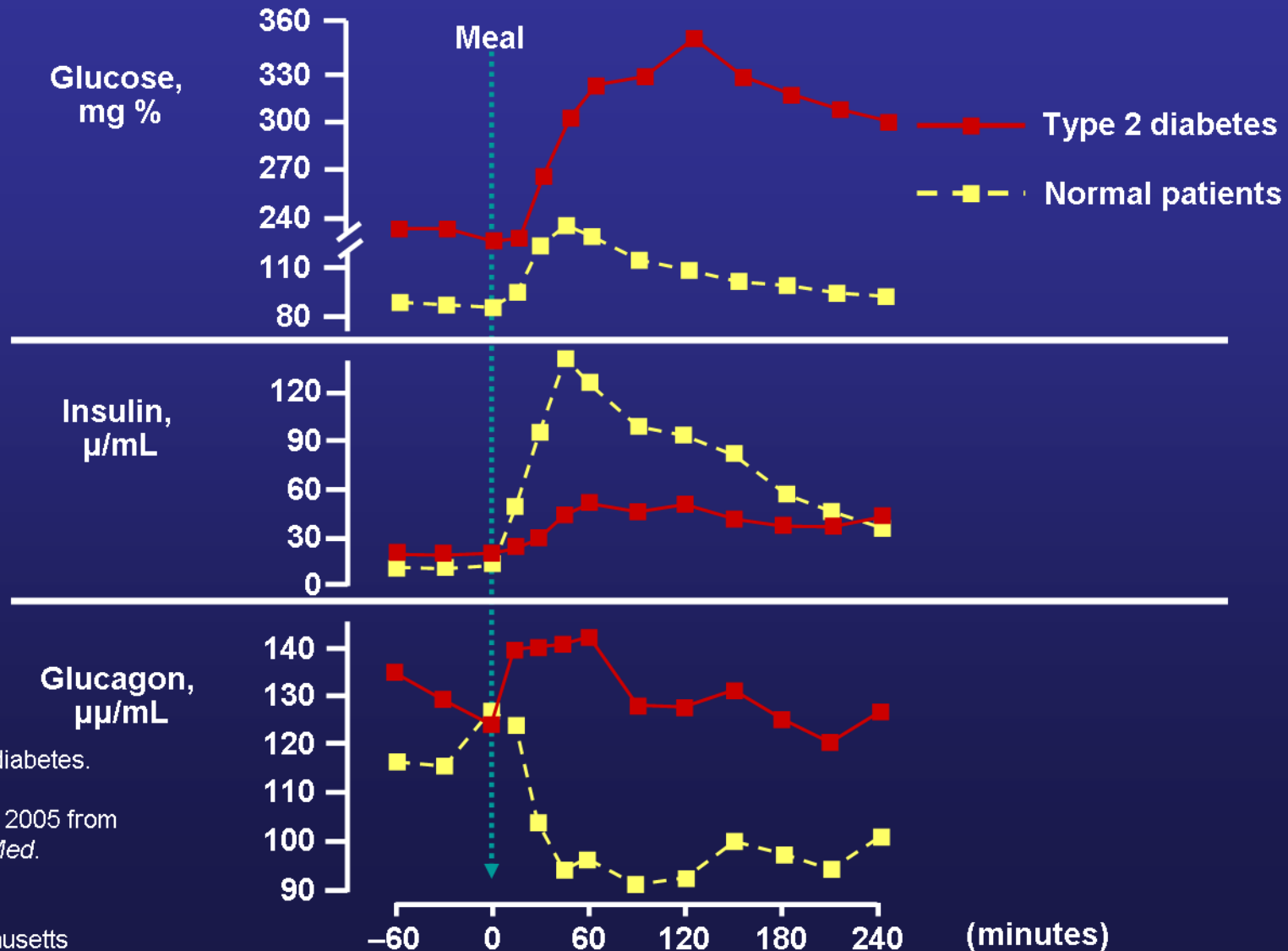
General caveats about diabetic therapeutics and hospital policy- patient safety

GLP-1 agents- not all of these are on formulary. Currently, they can be used but DM needs to be called to review.

Patients on weekly agents are an issue as well. Medicine reconciliation may not record these agents (Bydureon, Tanzium, Trulicity)

SGLT-2 not approved as of yet in house. Be aware of side effects and risks. (renal and DKA). Emerging data on cardiovascular benefit for events and mortality.

Insulin and Glucagon Dynamics in Response to Meals Are Abnormal in Type 2 Diabetes

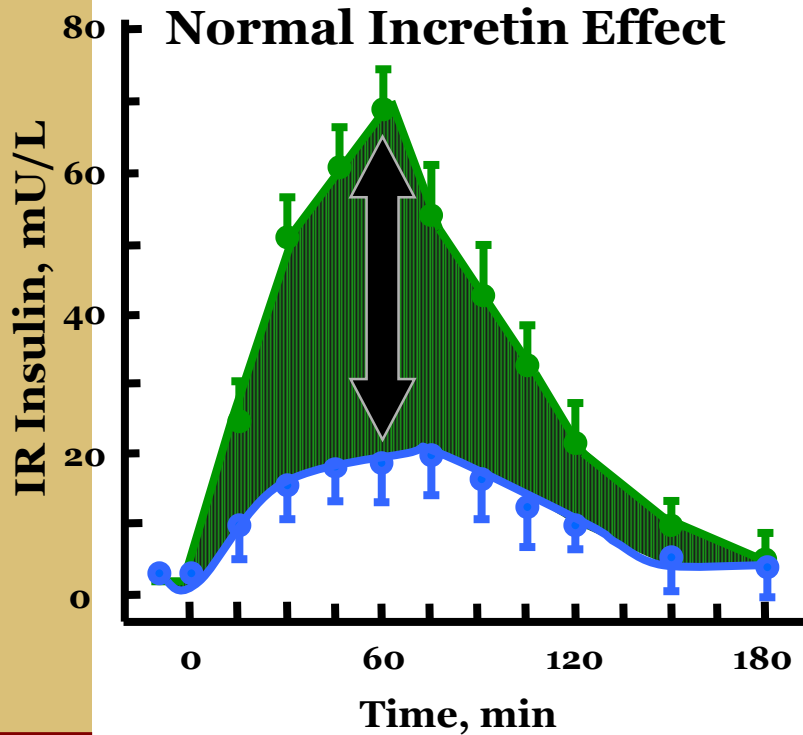


n=12 normal; n=12 type 2 diabetes.

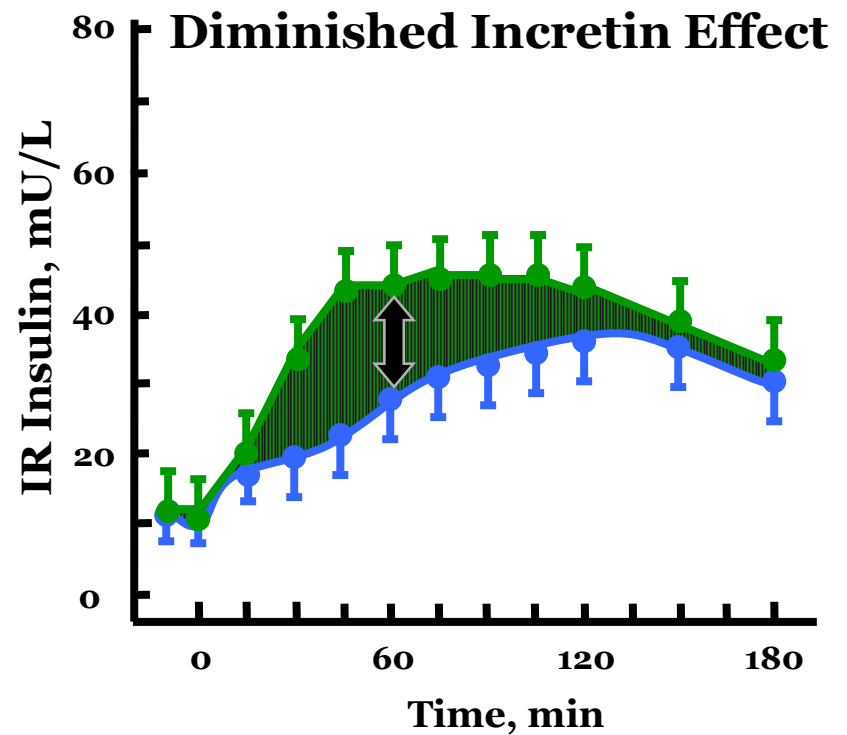
Adapted with permission in 2005 from
Müller WA et al. *N Engl J Med.*
1970;283:109-115.

Incretin Effect Diminished in T2DM

**Control Subjects
(n=8)**



**Subjects With Type 2 Diabetes
(n=14)**



IR=immuno-reactive

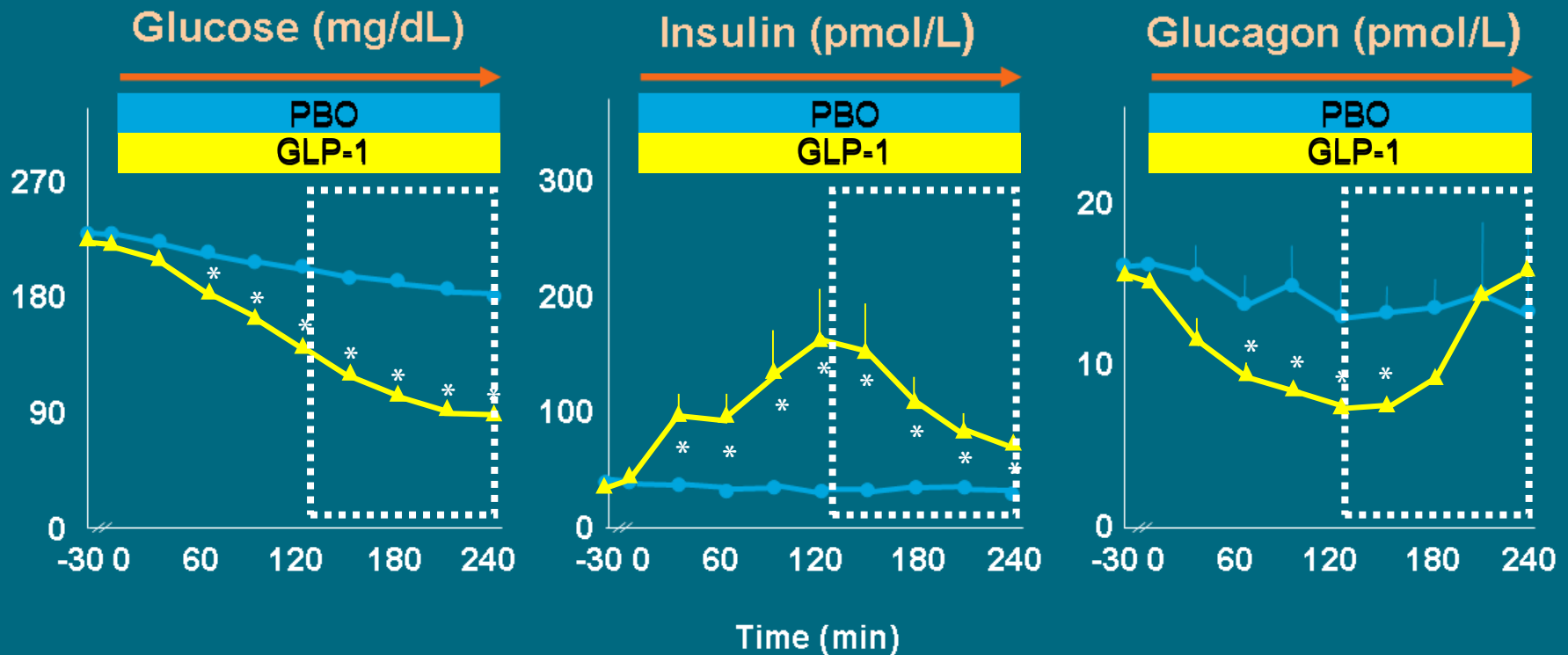
●—● Oral glucose load

●—● Intravenous (IV) glucose infusion

Glucose-Dependent Effects of GLP-1

Type 2 Diabetes (n = 10)

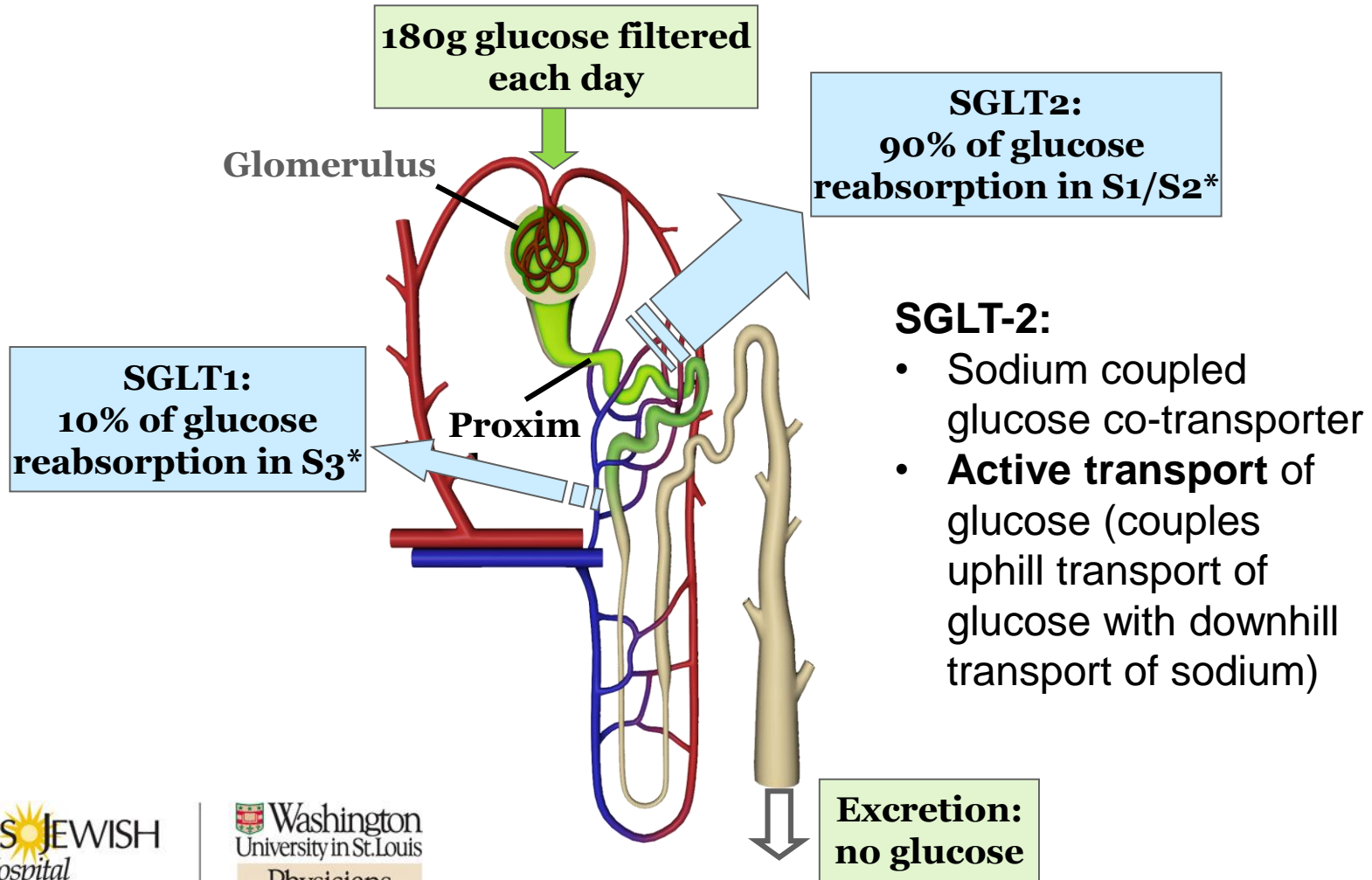
● Placebo
▲ GLP-1



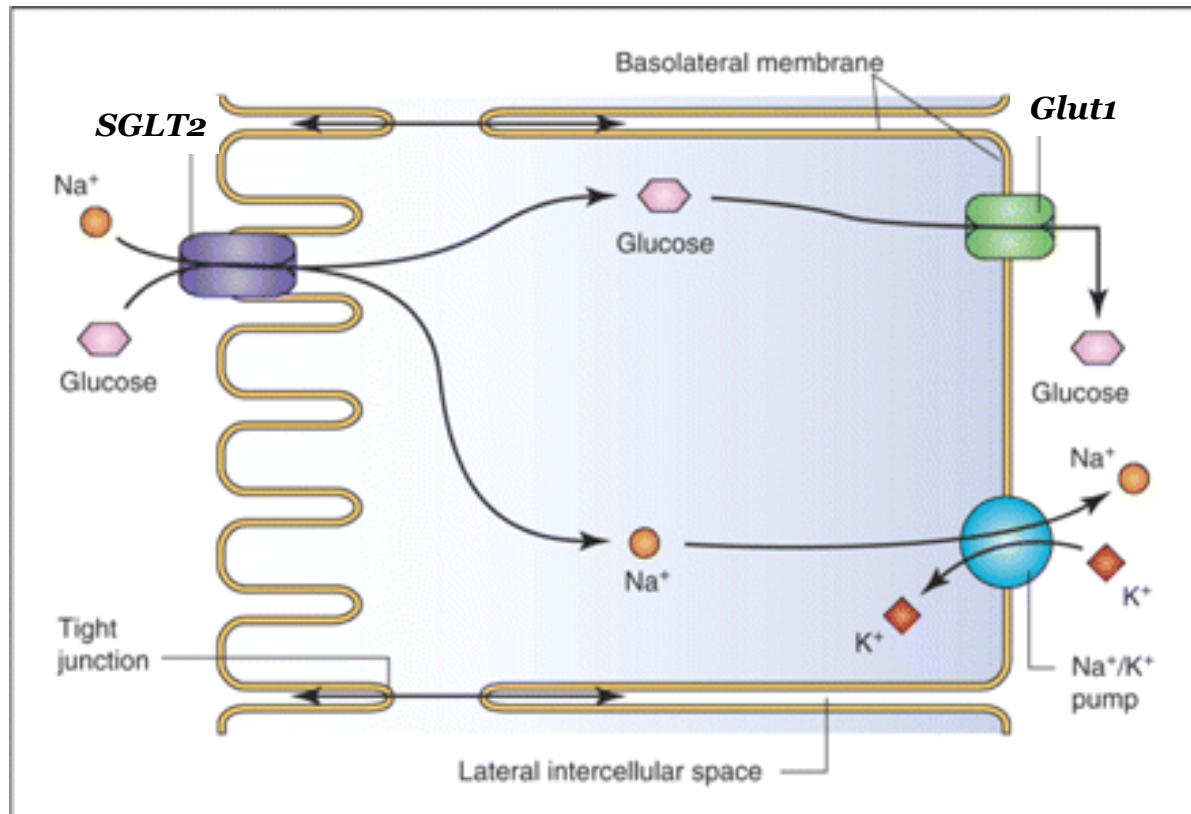
Mean (SE); * $P < 0.05$
Data from Nauck MA, et al. *Diabetologia*. 1993;36:741-744

Courtesy of Dr. McGill

Renal handling of glucose



Transmembrane transport of glucose and sodium: SGLT2



1 molecule of glucose is transported for every 1 molecule of sodium

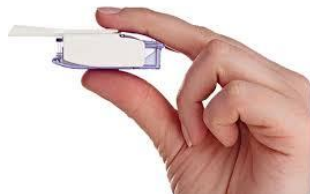
Hyperglycemia contributes to increased sodium reabsorption, possibly increasing BP, tissue edema

General caveats about diabetic therapeutics and hospital policy- patient safety

70/30 or any mixed insulin preparation are not on formulary. Transition needed to MDI therapy.

V-GO devices are not on formulary and an alternative regimen is needed.

**Afrezza- inhaled insulin is not on formulary-
Call diabetes service to review dosing and
consult on how to change to Sub Q.**



Management of Inpatient Diabetes Insulin Regimen

- **Use weight-based dosing**
 - ❖ Provide 50% of TDD as basal insulin (Glargine)
 - ❖ 50% as pre-meal divided by 3 meals (Lispro)
- **Compare home dose (reduced by 20% to 40 %) with the estimated weight based dose and utilize the safer dose.**



Insulin Dosing Recommendations

Insulin Sensitive

TDD (Units/kg)

No known DM- BG > 180

0.2

Pancreatectomy

0.2

AKI/CKD/ESRD/ESLD

0.3

Malnourished/elderly

0.3

T1DM

0.4

Insulin naïve T2DM, BMI < 30

0.3-0.4

Insulin Dosing Recommendations

Insulin Resistant

TDD (Units/kg)

Insulin naïve T2DM, BMI \geq 30

0.4-0.5

Insulin experienced T2DM

0.5-0.6

T2DM on steroids

0.5-0.6



Insulin Dosing Recommendations: Correction Insulin

AKI/ESRD/Pancreatectomy

Extra low dose

TDD < 40

Low dose

TDD 40-80

Mid dose

TDD > 80

High dose

Steroids

High dose



Additional Considerations

- **Correctional Insulin (sliding scale)**
 - Correctional insulin is a component of a basal/bolus regimen
 - Correctional insulin alone is generally not recommended
 - As a safety measure, avoid bedtime correctional insulin.
 - A lower scale is indicated, if given.



k5132583 fotosearch.com ©

Insulin Dosing Recommendation

Adjust Insulin Daily: and watch BG trends:

- If BG >100 – 140 mg/dl fasting OR >180 mg/dl random, increase 10-20%
- If BG < 100 mg/dl, decrease 10-20%

Increase mealtime insulin:

- If BG values are elevated at pre-lunch, pre-dinner, or bedtime

Increase basal insulin:

- If fasting BG >140 mg/dl AND BG drops less than 50mg/dl from bedtime to fasting



© Can Stock Photo - csp13853862

Insulin Dosing Recommendation

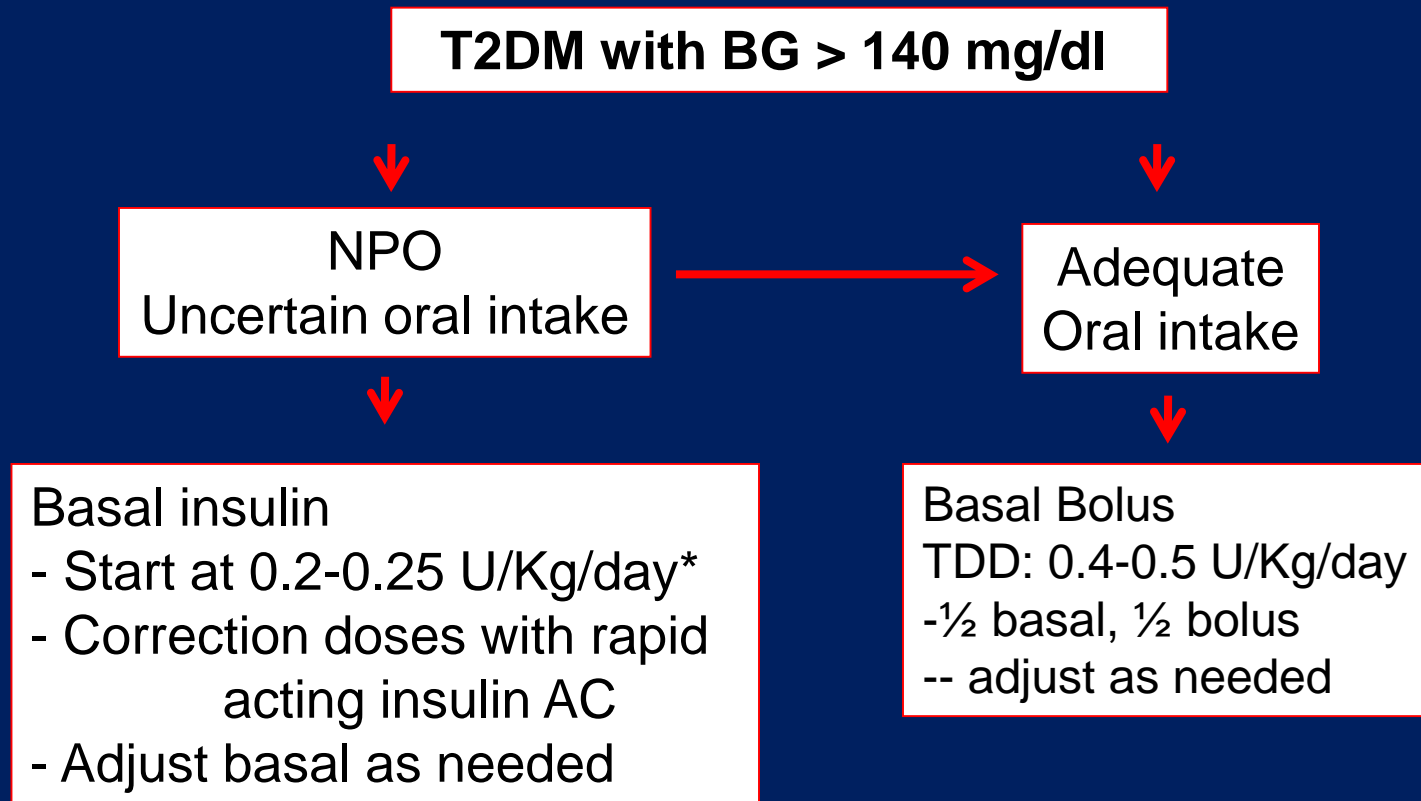
Daily Adjustment Alternative:

Can take half of previous 24 hour correctional insulin requirements:

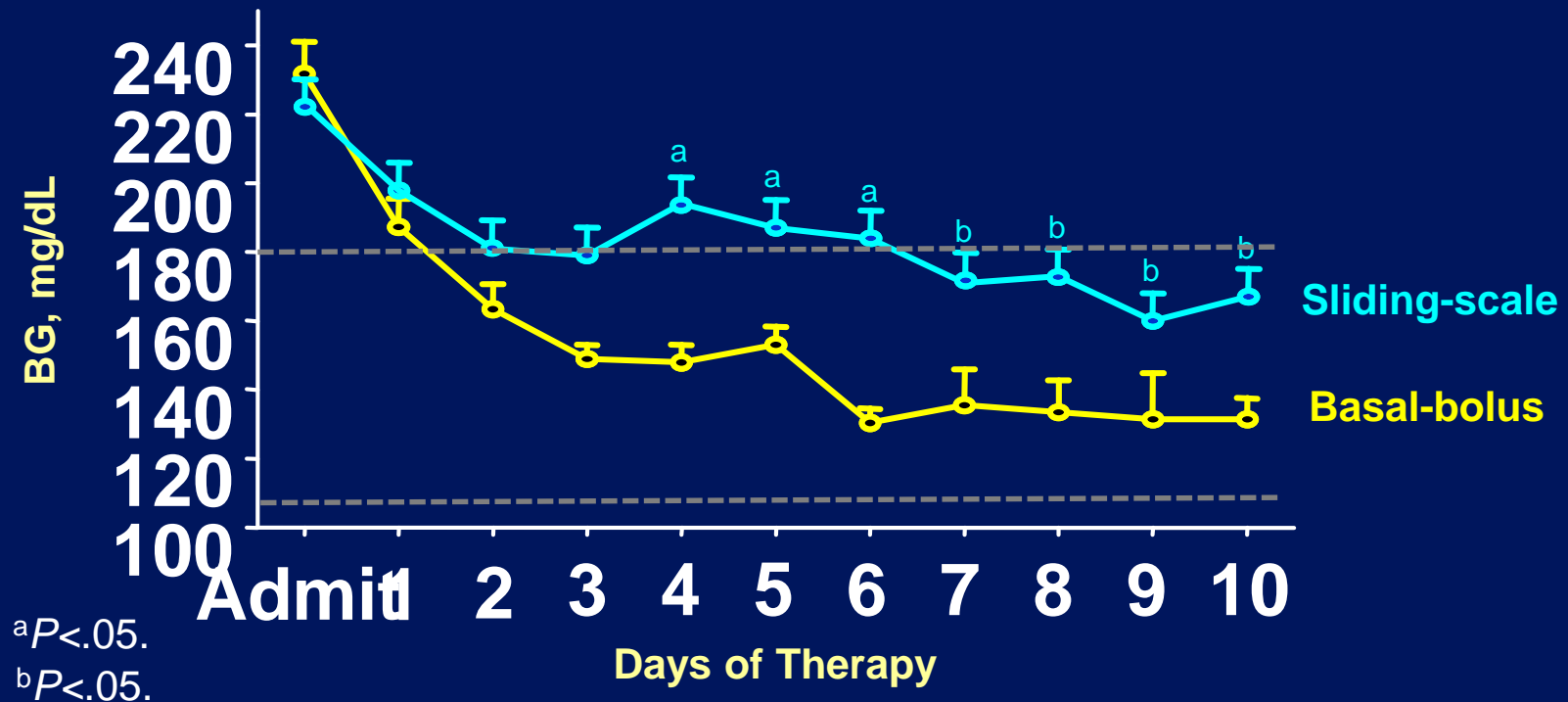
- ❖ Add half to basal
- ❖ And half to bolus insulin doses
- ❖ Or some variation of above



Do all patients need basal bolus ?



Rabbit 2 Trial: Changes in Glucose Levels With Basal-Bolus vs. Sliding Scale Insulin



- Sliding scale regular insulin (SSRI) was given 4 times daily
- Basal-bolus regimen: glargine was given once daily; glulisine was given before meals.
 - 0.4 U/kg/d x BG between 140-200 mg/dL
 - 0.5 U/kg/d x BG between 201-400 mg/dL

For Patients Eating Meals

Carbohydrate counting:

- ❑ **Insulin-to-Carbohydrate (I:C)** How many units of insulin to cover a specified number of carbohydrate grams at each meal.
- ❑ **Carbohydrate consistent diet at BJH** has 60 gm of carbohydrates. Example: 1:10 I:C ratio= 6 units of insulin to cover 60 gm carbohydrates.
- ❑ **Can be used to cover snacks**

If not carbohydrate counting, use weight-based TDD calculated from table above and give 50% of that TDD as basal, and 50% as mealtime bolus insulin divided across three meals

Carbohydrate ratio: $500 \div \text{Total Daily Dose (TDD, in u)}$



Insulin Sensitivity

The “Correction Scale” selection is based on TDD and implied insulin sensitivity.

Rule of 1500:

- $1500 \div \text{TDD of insulin}$ total daily dose
- Estimates glucose lowering effect of 1 unit of insulin

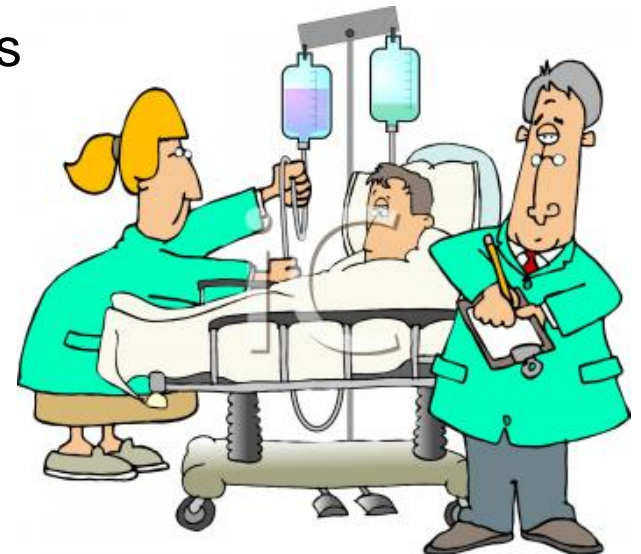


Bolus Tube Feeds

Calculate TDD from weight-based estimate

For bolus feeds:

- Give 50% as basal insulin and 50% as rapid-acting insulin divided equally among bolus feeds.
- Calculate the carbohydrates in the bolus and use an appropriate ratio to calculate the bolus amount.
- Blood Glucose POC testing Q 4 hours



Continuous Tube Feeds

Calculate TDD from on weight - based estimate

For continuous feeds:

- Give 40% as basal and 60% as rapid-acting divided equally q4-6hrs.
- Estimate the carbohydrates in 4 hours, and use an appropriate ratio to calculate the bolus amount
- POC blood glucose testing Q 4 hours with slide
- At discharge can transition to NPH to cover cycled tube feeds
- Insulin pumps – can do square wave bolus over 8 hours or a temp basal

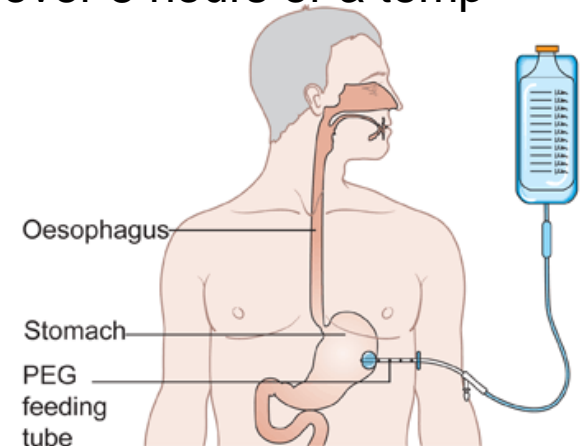


Diagram showing the position of a percutaneous endoscopic gastrostomy (PEG) feeding tube
Copyright © CancerHelp UK

Nutritional Insulin

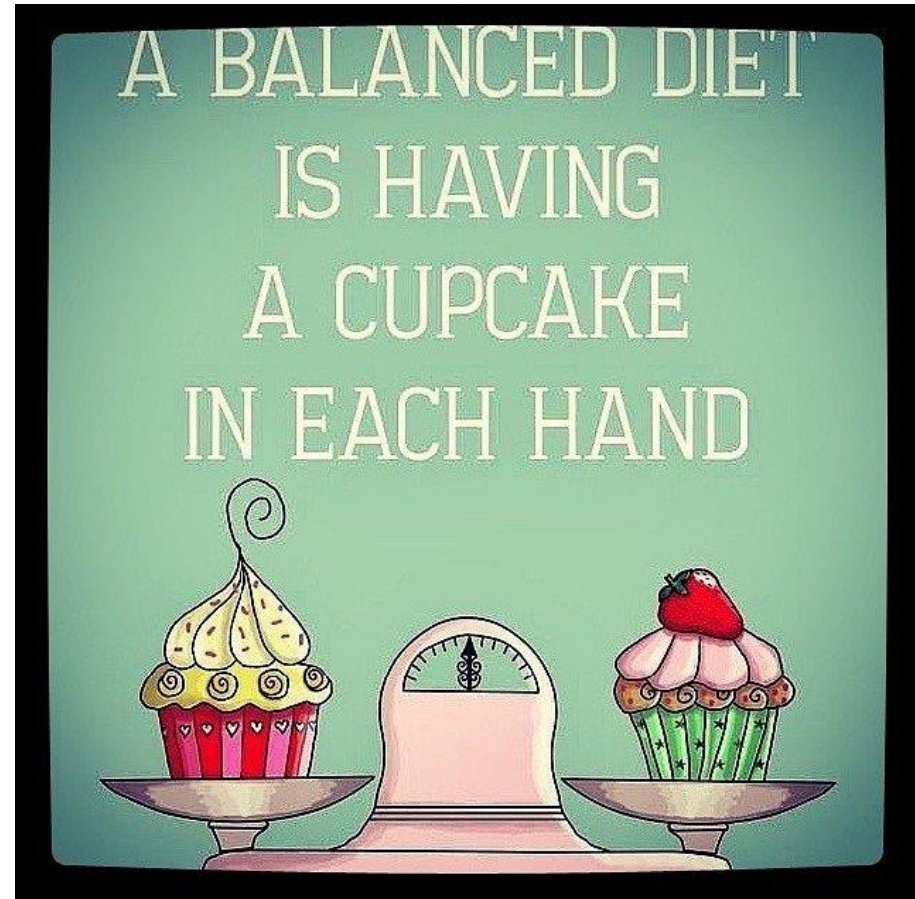
TPN: Regular insulin is usually included in the TPN formulation:

- Use the estimate for carb counting based on formula or start at a 1/10 ratio.
- At our institution, we use IV regular insulin placed in TPN bag
- The need for insulin is higher for IV than for enteral feeds.
- May need more insulin for TPN with lipids
- Use q4hrs correction insulin
- Adjust daily
- For hyperglycemia, can cover with NPH or hold TPN



BEWARE OF “Nutritional Sabotage”

DIET is an
Important part
of patient’s
treatment



NPO Patients

- **Follow NPO insulin orders sets/collaborate with physician as necessary**
- **May give up to half of the basal insulin dose, hold the mealtime insulin, and continue the correction dose**
- **Monitor BG every 4-6 hours and give corrective insulin as needed/and ordered**
- **Resume the previous regimen once the patient is eating again**

NPO Continued

- Ideally, patients with diabetes should have surgery early in the morning to avoid a prolonged NPO period
- NPO patients need regular blood glucose monitoring (every 4-6 hours) and may need IV fluids containing dextrose
- May still need correctional insulin, should be per NPO scale



TRANSITION FROM IV INSULIN

The stress of surgery is greatest immediately post op and then generally improves over the next 2-3 days.

- **Pre- existing diabetics: rule of thumb is to take 80% of the prior 24 hour insulin needs and use that as a guide to dose the next 24 hours. This 20% reduction is used for up to 3 days or until dosing is in line with weight or home dosing.**
- **Stress Hyperglycemia or non diabetic- Use 60% reduction factor.**
- **Be cognizant of the effects of pressors, especially Epinephrine, on insulin needs.**
- **Use the drip requirements over 24 hours or the last 6 hours if most stable to estimate dosing.**

Insulin Dosing - Steroids

Steroid-induced Hyperglycemia

- Convert steroid to Prednisone equivalent:
 - Prednisone 20mg = Methylprednisolone 16 mg = Dexamethasone 3mg
- For patients on > 100 mg prednisone equivalent per day, recommend diabetes consult.
- For patients on 40-100 mg prednisone equivalent per day (with diabetes or BG>180 mg/dl):

Select one of the following

Insulin naïve or Prednisone Dose of <40mg:

- If steroid dosed once daily, Add Insulin NPH 10 units given with steroid dose
- If steroid dosed multiple times daily, Add Insulin rapid-acting (e.g. Lispro) 3 units with each meal
- Adjust dose by 10-20% daily to meet blood glucose goals

Insulin Resistant or Prednisone Dose of >40 mg:

(Prednisone equivalent (mg)-20) x 0.1 units x bodyweight (kg)
20

Maximum initial single dose: 20 units insulin naïve

40 units insulin experienced

- Give NPH concurrently with each steroid dose in multi-dose or daily steroid regimens
- If receiving an evening NPH dose, order an additional 0200 POC glucose

Hyperglycemia Urgency

Acute Treatment

- A. NPO except encourage water, coffee, and tea (unless fluid restricted).
- B. R/O DKA Obtain a BMP as necessary.
- C. Is patient on corticosteroids? See steroid-induced hyperglycemia protocol below.

Choice of 3 management options: (Consider Diabetes Consult – 747-ENDO)

1. Give a correction dose of rapid-acting insulin which is 5%-10% of the weight-based TDD as calculated from the dosing table on the front of card.
 - a. Avoid “insulin stacking” by separating multiple of doses by at least 3 hours.
 - b. Remember, short-acting insulin peaks at 1-2 hours. Do not repeat BG check before 1 hour.
2. Use the Hyperglycemia Urgency order set in Compass as necessary.
3. Transfer patient to an ICU for Insulin drip if DKA or HHS.



Hyperglycemia Urgency Set: Dosing Guideline

Blood glucose value	Recommendation	Typical IV dose
250-299 mg/dL	Bolus: No IV bolus, provide SQ insulin.	No IV insulin
300-399 mg/dL	Bolus: ≤ 0.05 u/kg	3-5 units
400-449 mg/dL	Bolus: ≤ 0.07 u/kg	5-7 units
>450 mg/dL	Bolus: ≤ 0.1 u/kg	7-10 units

CORRECTIONAL INSULIN. **CONTINUOUS INTRAVENOUS INSULIN INFUSIONS (INSULIN DRIPS) ARE ALLOWED ONLY IN THE ICUs, PCUs, AND LABOR AND DELIVERY AREAS. ****SEE THE IV GUIDELINES FOR FULL DETAILS ON THESE RESTRICTIONS.

COMMENTS:

**The doses suggested in this order set are meant to be a general guideline only. Insight regarding historical insulin requirements should also be considered when determining insulin doses.

**Patients with hyperglycemia and clinical deterioration should be managed in the ICU or PCU. This may include the following characteristics (not an all-inclusive list): potassium <4 mEq/L, bicarbonate <15 mEq/L, or experiencing severe symptoms such as coma, metabolic compromise, or hypotension.

**Patients requiring more than three doses of intravenous insulin boluses in a 24 hour period for hyperglycemia urgency should be managed in an area with high level of acuity and observation (ICU or PCU).

**All dextrose containing fluids should be discontinued in patients experiencing hyperglycemia urgency.

**Tube feeds should be held temporarily (1-2 hours) in patients with hyperglycemia urgency.

**Insulin orders should be reviewed by the prescriber or covering health care professional and altered if appropriate in patients experiencing severe hyperglycemia.

**The diabetes service can be contacted for assistance with the management of patients experiencing hyperglycemia urgency. The diabetes fellow can be reached via pager number 424-6259.

Reason For Hyperglycemia:

Suboptimal insulin dosing/ titration; Missed insulin doses Clear

- Corticosteroid use Missed insulin doses Changes in dietary intake
 Suboptimal insulin dosing/ titration Other/unknown

Obtain BMP stat if not performed within the last 4 hours

Labs (STAT):
 BMP Plasma

Diet Order:

Order	Requested Date	NPO Except	Frequency	Duration	Additional Information
<input type="checkbox"/> NPO					
<input type="checkbox"/> Hold Tube Feeding					

Nursing Instructions/Communication:

Order	Additional Information
<input type="checkbox"/> Nursing Bedside Testing Communication	

Intravenous Insulin Monitoring:

Order	Frequency	Additional Information
<input type="checkbox"/> Glucose Point of Care		
<input type="checkbox"/> Glucose Point of Care		

Hyperglycemia Urgency [1 orders of 7 are selected]

Reason For Hyperglycemia:

Suboptimal insulin dosing/ titration; Missed insulin doses

Clear

- Corticosteroid use
 Missed insulin doses
 Changes in dietary intake
 Suboptimal insulin dosing/ titration
 Other/unknown

Obtain BMP stat if not performed within the last 4 hours

Labs (STAT):

BMP Plasma

Diet Order:

	Order	Requested Date	NPO Except	Frequency	Duration	Additional Information
<input type="checkbox"/>	NPO					
<input type="checkbox"/>	Hold Tube Feeding					

Nursing Instructions/Communication:

	Order	Additional Information
<input type="checkbox"/>	Nursing Bedside Testing Communication	

Intravenous Insulin Monitoring:

	Order	Frequency	Additional Information
<input type="checkbox"/>	Glucose Point of Care		
<input type="checkbox"/>	Glucose Point of Care		

SUGGESTED INITIAL DOSES:

Blood glucose 250-299 mg/dL	Bolus: No IV bolus, provide subcutaneous insulin Typical Intravenous Dose: No IV bolus, provide subcutaneous insulin
Blood glucose 300-399 mg/dL	Bolus: < or equal to 0.05 units/kg IVP Typical Intravenous Dose: 3-5 units IVP
Blood glucose 400-449 mg/dL	Bolus: < or equal to 0.07 units/kg IVP Typical Intravenous Dose: 5-7 units IVP
Blood glucose > 450mg/dL or critical high	Bolus: < or equal to 0.1 units/kg IVP Typical Intravenous Dose: 7-10 units IVP

Insulin Bolus Order:

	Order	Dose	Units	Route	Frequency	Indication	Comments
<input checked="" type="checkbox"/>	Insulin Regular for HumuLIN-R	5	unit	subcutan...	NOW	hyperglycemia	limit dose 3-10 units

Other Insulin Orders:

<input type="checkbox"/>	Standard Subcutaneous Insulin Orders
--------------------------	--------------------------------------

Drug Info

Insulin Algorithm

Transition to Home

Discharge Recommendations

A1C < 7%

Re-start outpatient treatment regimen (OAD and/or insulin)

A1C 7%-9%

Re-start outpatient oral agents and D/C on glargine once daily at 50-80% of hospital dose

A1C >9%

D/C on basal bolus at same hospital dose.

Alternative: re-start oral agents and D/C on glargine once daily at 80% of hospital dose

Approach to the management of hyperglycemia

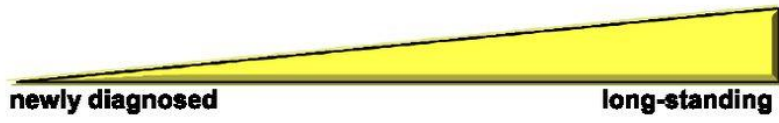


PATIENT / DISEASE FEATURES

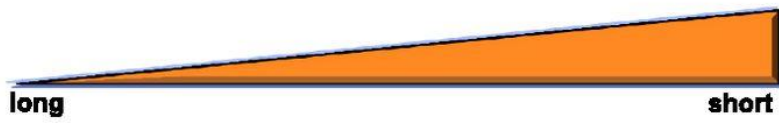
Risks potentially associated with hypoglycemia and other drug adverse effects



Disease duration



Life expectancy



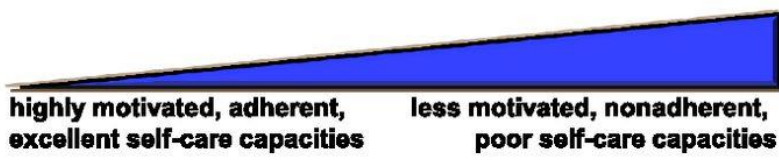
Important comorbidities



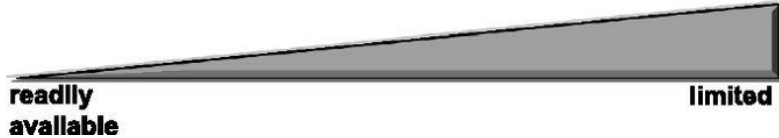
Established vascular complications



Patient attitude and expected treatment efforts



Resources and support system

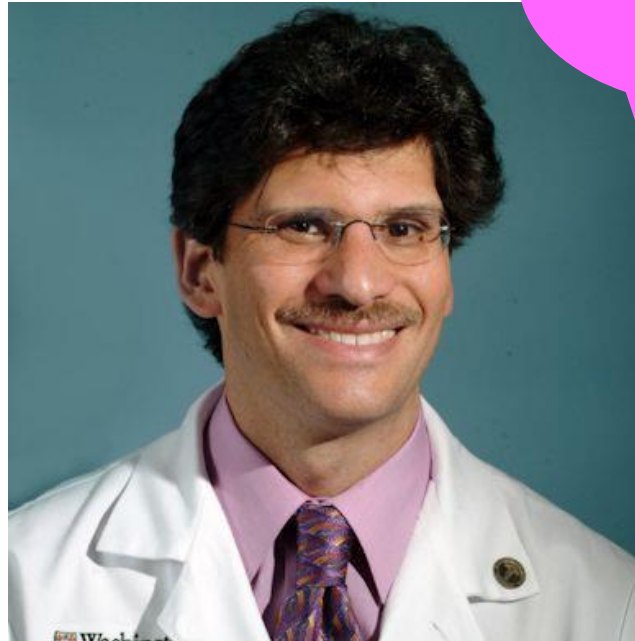


Usually not modifiable

Potentially modifiable

Can We Control and Prevent Severe Hyperglycemia?

Yes!



Hyperglycemia prevention

Structured order sets and sliding scales

We are in the process of setting up a control room surveillance system for glycemic control

Educational modules

We are in the process of developing a predictive steroid alert.

Protocols for steroids

Standardization of insulin therapy in Surgery and for tube feeds

Flag patients with T1DM

Flag patients with insulin pumps

Multi-disciplinary team

Consult your friendly Diabetes Service



QI Project

The Holy Grail - Preventive Alert

Team:

Garry Tobin, MD, Project Lead Physician

Cynthia Herrick, MD, Project Lead Physician

Clare Blackburn, RN, CDE, Project Lead Nurse

Paulina Cruz-Bravo, MD

Libby O'Connor, RN, MSN, CDE, ANP-BC

Aims

What we are trying to accomplish:

- To improve providers' knowledge and awareness of inpatient glycemic control.
- Decrease severe hyperglycemia (>299mg/dl) events/rate by 20%.



© Ron Leishman * www.ClipartOf.com/439074

Reducing Hyperglycemia - QI

- **Follows the Plan-Do-Study-Act (PDSA) model**
 - ❖ Surveyed all providers at BJH to understand practitioners' knowledge and barriers to addressing inpatient hyperglycemia.
 - ❖ Created a real-time severe hyperglycemia alert per the Pharmacy Expert System (PES). The alert is directed per email to the Diabetes Specialist Team (DST) for analysis.

Reducing Hyperglycemia - QI

- ❖ The DST is comprised of four endocrinologists and two nurse certified diabetes educators.
- ❖ The team acted on the alerts with “Just-in-Time Teaching” to prescribers at BJH.
- ❖ The teaching included a recommendation for insulin order changes, and provision of a pocket card with weight-based dosing guidelines and treatment approaches to severe hyperglycemia.

Hospital metrics for Severe Hyperglycemia to allow comparison across institutions in BJC

Metric

- BG > 299mg/dl
- Cap of 600mg/dl (otherwise likely to be a lab error)
- Begin the collection 12 hours after admission
- Allow only one event for 12 hours
- Remove if non-alerting value is reported within 10min – error from Line
- Rate Denominator is number of events per 1000 patient days (not adjusted)

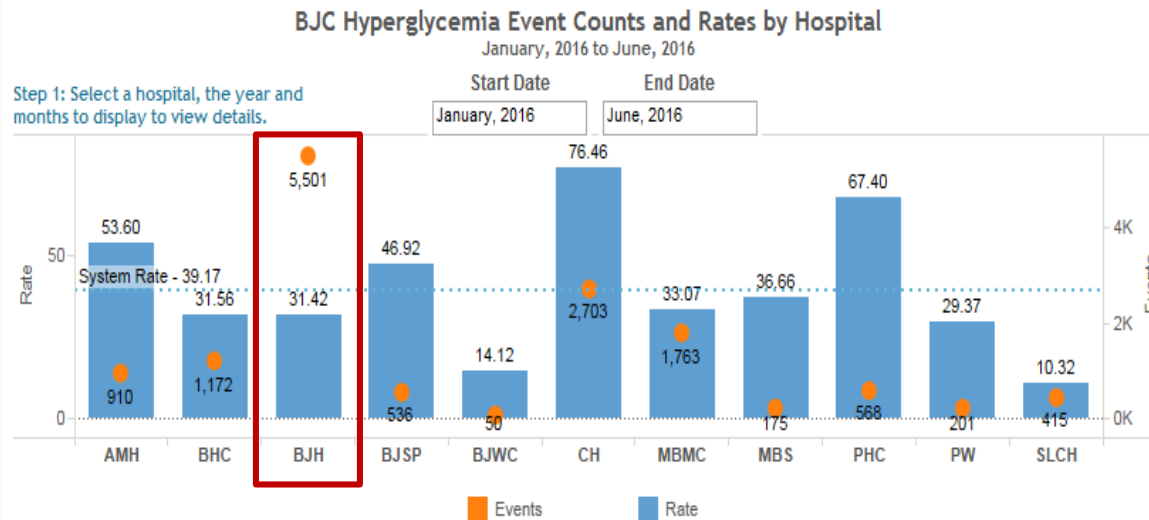
Methodology

- Numerator: Number of hyperglycemic events
- Denominator: Number of in-patient days
- Event monthly rate per 1,000 patient days

Severe Hyperglycemia Events

Blood glucose >299 mg/dL

- In 2014, the rate at BJH was 41/ 1000 patient days, down to 30/1000 patient days in 2016.
- This reflects a **27.5% reduction**.



Hospital Hyperglycemia Event Counts and Rates by Month

Diabetes is a comorbid condition in **25%** of BJH admissions

Slide courtesy of Dr. Tobin

Limitations of insulin use

- **Most ERROR prone medication-hospital**
- **Labor intensive**
 - ICU —
 - Hourly checks/Complex calculations
 - Non-ICU
 - Meal timings/Proportion of meal ingested
- **Needs training for appropriate use**
 - Extensive use of sliding scale
- **Hypoglycemia**

ISMP: Why Are Insulin Medications So Prone to Error?

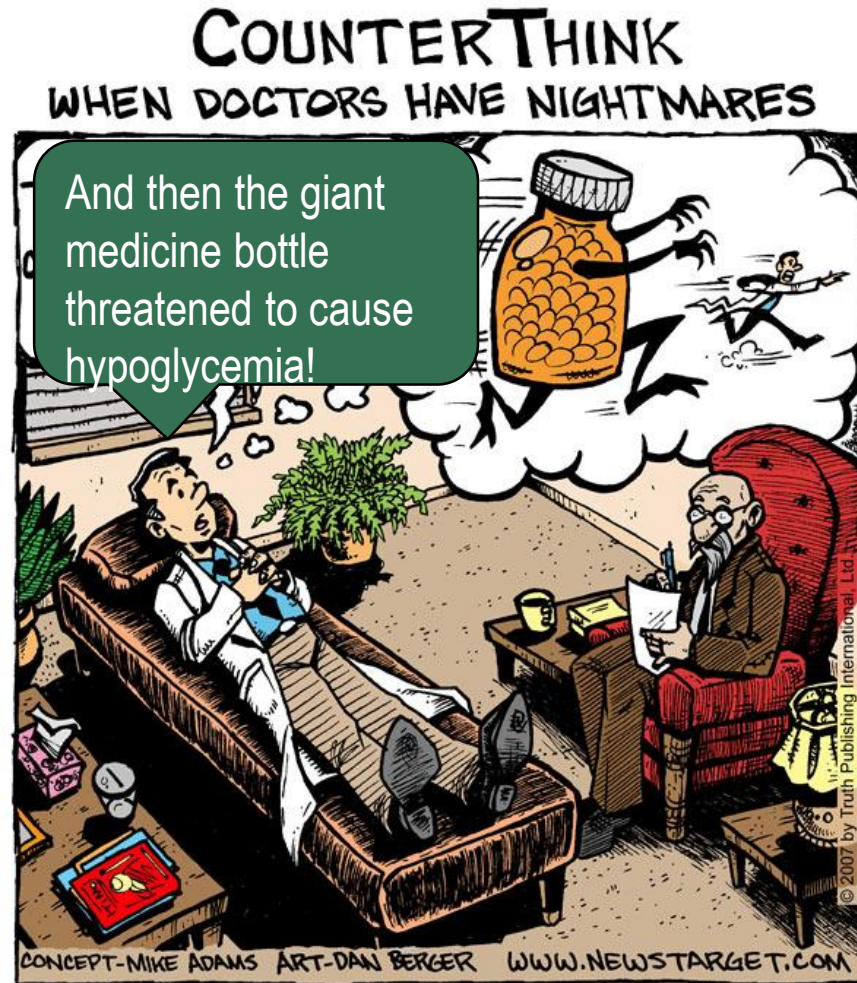
From The Institute For Safe Medication Practices: Insulin accounts for more than 10% of all drug mistakes. This drug class has been rated as having the most mistakes every year for the last 20 years

Each glucose determination required 7 minutes of nursing time; a nurse caring for 2 patients on the insulin protocol would spend approximately 2 hours of a 12-hour shift monitoring the patient, obtaining samples, performing tests, and intervening.

Sliding Scale Insulin—Time to Stop Sliding

Hypoglycemia increased mortality, length of hospital stay in patients with diabetes

Can hypoglycemia be prevented and controlled?



Inpatient Hypoglycemia

Multifactorial:

- Excessive insulin dosing (per body weight, etc)
- Medication errors
- Inappropriate timing of insulin with food
- Changes in nutrition status (NPO)
- Impaired renal function
- Insufficient glucose with insulin for treatment of acute hyperkalemia
- Inadequate monitoring of BG values
- Changing meds known to affect BG (steroids)
- Failure of effective nurse-MD communication

Errors in Insulin Administration



Is Hypoglycemia Dangerous?

- A prior history of hypoglycemia and the duration of an individual episode is related to the outcome of the patient.
- Treat all hypoglycemia seriously!
- The nurses have a graded protocol for treating low blood sugars and should call for all lows.
- The body has a graded response to lows with counter-regulatory hormones being released around 70 mg/dL and a BG < 50 associated with neuro-cognitive deficits.

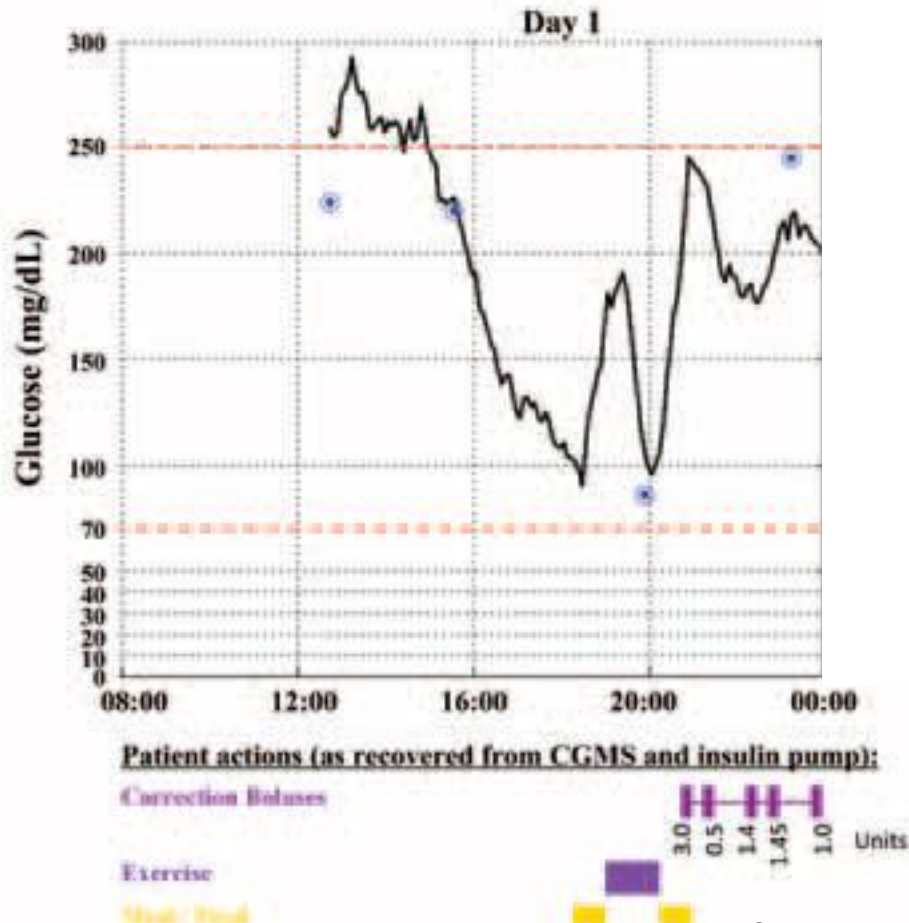


Courtesy of Dr. Tobin

Dead-in-Bed Syndrome

Tanenberg et al., Endo Practice, 2010

- 23 year old man with a history of Type 1 diabetes since age 11
- Recurrent hypoglycemia (nocturnal and post-exercise)
 - Insulin pump at age 20
 - HbA1c 6.4%
 - Following a hypoglycemic seizure, basal insulin infusion rates lowered and continuous subcutaneous glucose monitor ordered



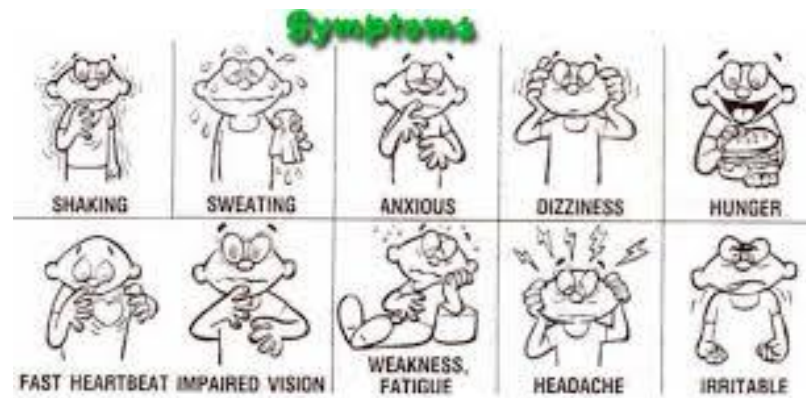
The Problem: Inpatient Hypoglycemia

- **Too common: prevalence of hypoglycemia <70 mg/dL in 2009 estimated at 5.7%**
- **Associated with increased mortality and length of stay**
- **Associated with increased cardiovascular, cerebrovascular, and patient fall events**
- **Expensive**
 - CMS has designated severe hypoglycemia (BG<40mg/dL) with harm as a “never event” and will not pay for adverse associated outcomes
- **Providers do not consistently adjust patient regimens in the hospital to prevent hypoglycemia.**

Hypoglycemia CAN be Prevented

1. We developed a real time predictive alert to prevent hypoglycemia, using factors from a retrospective review of our patients:

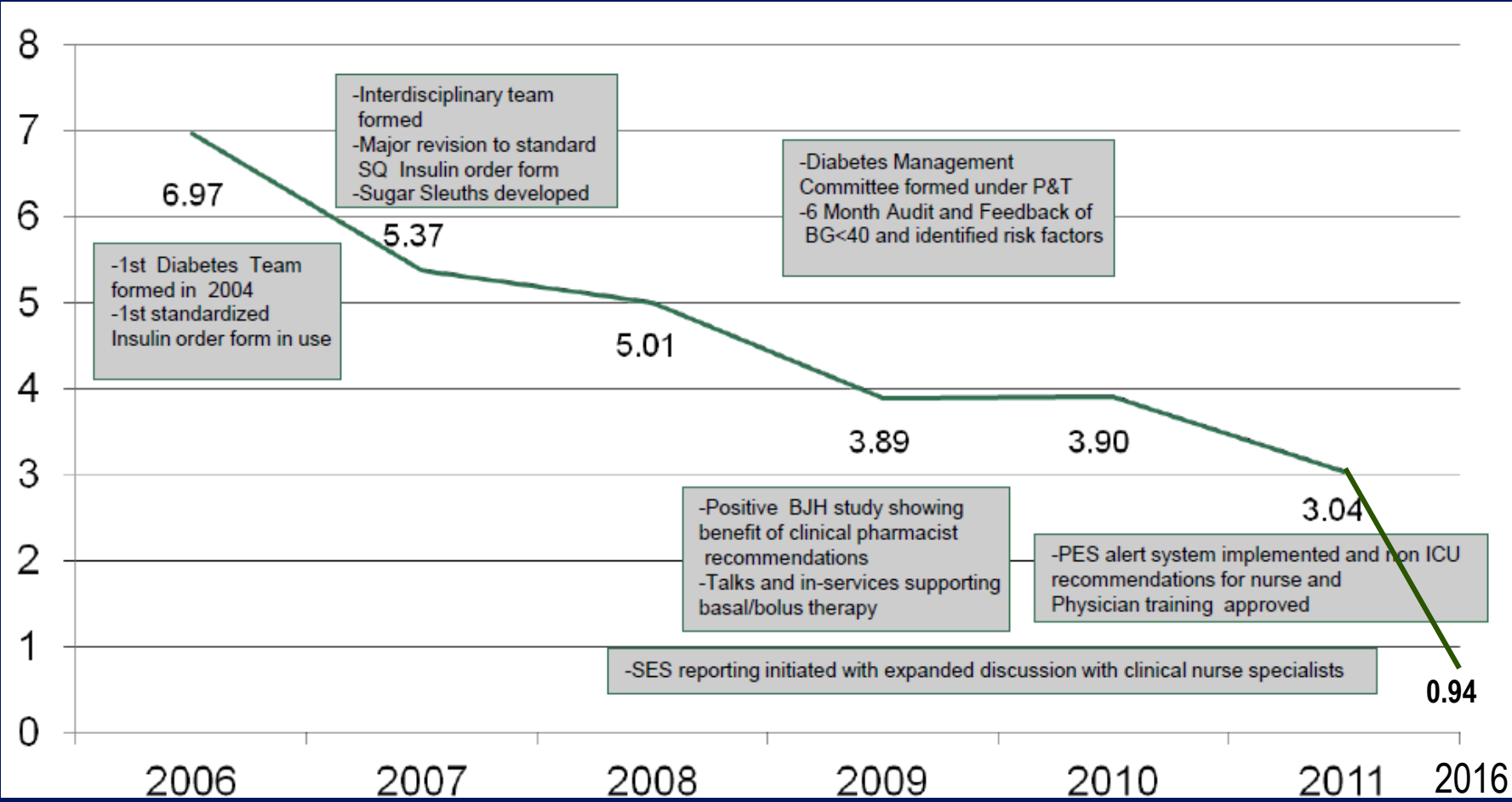
- Age
- CrCl
- One BG reading < 90
- Weight
- Patients had to be on insulin therapy



2. PES alert was trialed on limited units, was successful in significantly reducing the rate of severe hypoglycemia, and is now implemented across the BJC system

Inpatient Severe Hypoglycemia (BG < 40 mg/dL) at BJH: 2006-2016

Hypoglycemia episodes/1000 at-risk patient days



Courtesy of Drs. Tobin and CR Kilpatrick, Washington University SOM

Closer to home at BJH

Patient treated for hyperkalemia on the medicine floor.

K: 5.6 no EKG changes

Resident orders 10 units IVP regular insulin and 1 amp D 50

Patient became unresponsive with a Blood sugar in the 30's
Code called: intubation difficult and coded

Passed away 3 days later.

Hyperkalemia order set developed, and uses 50 grams Glucose,
Monitoring of blood sugars 1,3 and 6 hours later.



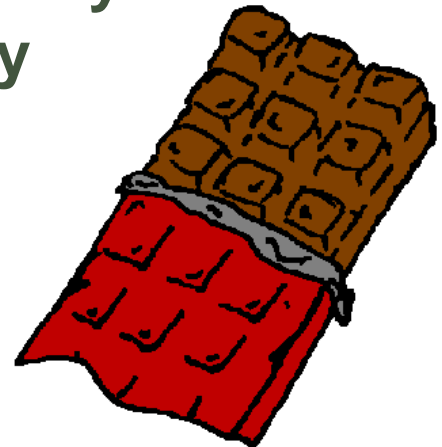
Top Eight Things You need to Know about Inpatient Diabetes Management

8. If carbohydrates are nearby the patient **CAN** and **WILL** eat them.
7. If carbohydrates are not available, the patient will go to the **CAFETERIA** to get them.
6. If you cannot find a patient, who is on the **Severe Hyperglycemia Order Set**, look in the cafeteria.
5. **Bedtime snack** means two containers of ice cream. **Snack insulin** will not be give, even if ordered



“Unexplained Hyperglycemia:” The Barnes Jewish Hospital Experience

4. Unexplained hyperglycemia...check the room for candy bars
3. Hypoglycemia treatment does not include 2 packages of graham crackers, milk ...and a “turkey sandwich.”
2. If the patient has severe hyperglycemia upon arrival to acute medicine floor, they may have been treated in the ER...with a turkey sandwich etc.... No insulin given.



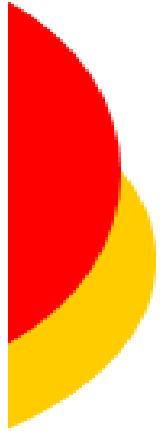
“Unexplained Hyperglycemia:” The Barnes Jewish Hospital Experience

1. Never be surprised--- a physician following-up on their patient with severe hyperglycemia ---treated with 10 units of regular insulin IVP ---

Was told the patient went with his family to the ZOO?! It was Father’s Day 😊



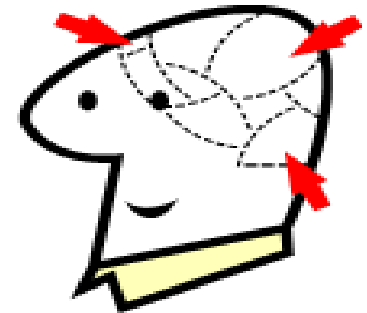
CASE STUDY



THE BRAIN

"The Brain is a wonderful organ. It starts the moment you get up in the morning and does not stop until you get to

Work!!!



STEROID CASE

67 year old, diabetic man is admitted with a COPD exacerbation, complicated by acute renal failure (ARF), and a myocardial infarction. At home he was on unspecified oral anti-diabetic medications.

The patients weight is 66 kg // A1C is 7.1%// Creatinine 2.0 mg/dl

He is on a consistent carbohydrate diabetic diet in the hospital.

Prednisone 60 mg is prescribed daily for COPD. He has been on prednisone 60 mgs for 3 days prior to the data on the next slide.

He is currently on Glargine (Lantus) 20 units each night and high-dose SSI q4 hours.

STEROID CASE

Time	BS (mg/dl)	Insulin Given
23:07	194	Glargine (Lantus) 20; Lispro (Humalog) 3 units
00:00	160	
01:40	112	
04:00	67	8oz of juice
07:33	235	Lispro (Humalog) 7 units; Prednisone reduced to 40mg
11:00	291	Lispro (Humalog) 9 units

Blood sugar of 39 occurred the following day.

STEROID CASE

Why is knowing the patient's home oral diabetic medication important?

How will the patient's ARF affect his glycemic control?

How will the patient's steroid affect his glycemic control?

Is the frequency of the finger sticks correct?



STEROID CASE

The A1C at home suggests that his control was overall in an acceptable range.

Patients treated with Metformin, the DPP4 inhibitors (Januvia, Onglyza, Tradjenta), GLP-1 agonist injectables and the thiazolidinediones are at a lower risk of hypoglycemia.

Patients on a sulfonylurea's (i.e. Glyburide), or a combination of a sulfonylurea with one of the above therapies, would be at greater risk for hypoglycemia, especially with an A1C at 7.1%.

The lack of knowledge of the medications at home and the ARF should raise alarms.

The frequency of the POC testing is not correct if eating- should be TID and Bedtime.

Steroid case additional questions

What adjustments should be made for this patient's Prednisone dose now of 40 mgs?

His regimen of 20 units Glargine and slide is clearly wrong.

Recommend a hospital regimen for this patient.



Steroid case

The patient weighs 66 kg and 0.5Units/Kg provides 33 units of total daily insulin for a patient with normal renal function.

Dosing is reduced to 0.3 Units per Kg for the patients with ARF/ESRD. A low-dose adjustment scale would also be appropriate.

Steroids have variable effects and differ if dosed at night or during the day.

We often use NPH to assist in covering the steroid effect.

Steroid Formula (40 mgs-20 mgs)/20 mgs X(66 kgs)X (0.1 units per kg)= 7 units

STEROID CASE

The recommended dosage of an MDI regimen 0.3 per kg with a supplemental dose for the steroids.

- *Glargine (Lantus) 10 units at bedtime*
- *Lispro (Humalog) 3units with meals + low dose adjustment scale*
- *POC testing TID at meals and bedtime*
- *NPH 7 units for the 40mg prednisone dose given in the am.*

THANK YOU!

