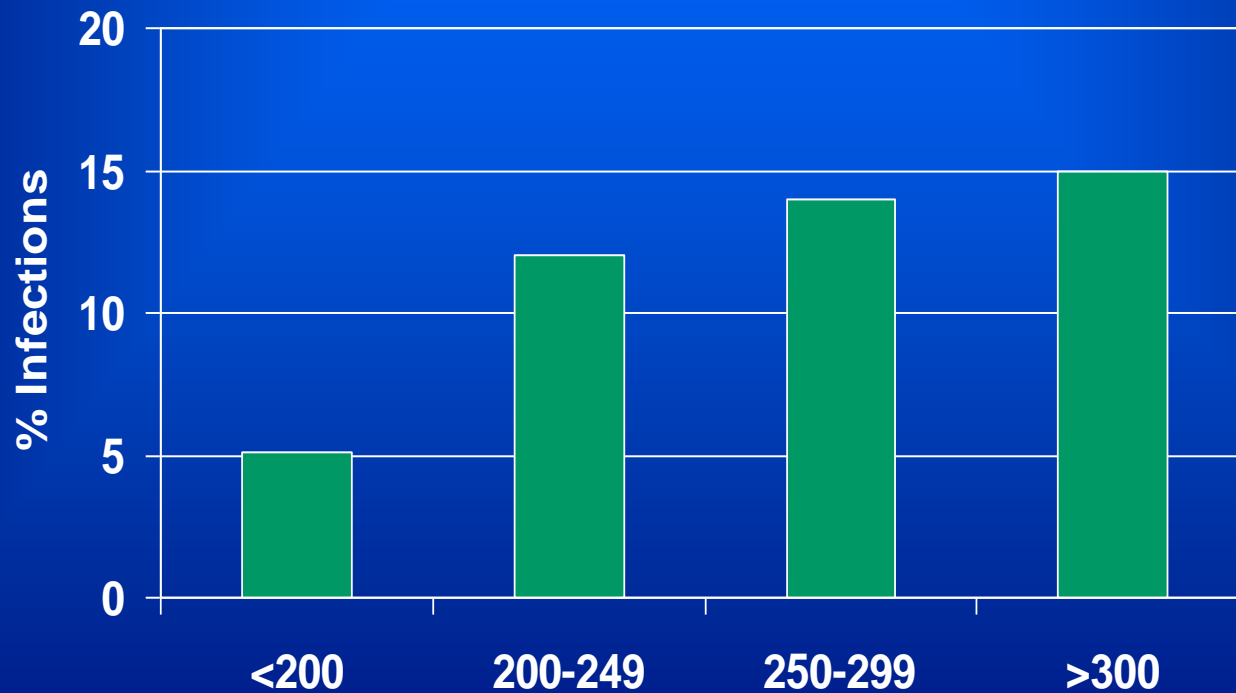


**Hyperglycemia is  
Dangerous to NonDiabetics  
(and Diabetics)**

**E. Patchen Dellinger, MD  
University of Washington**

# Glucose Control and SSIs After Median Sternotomy



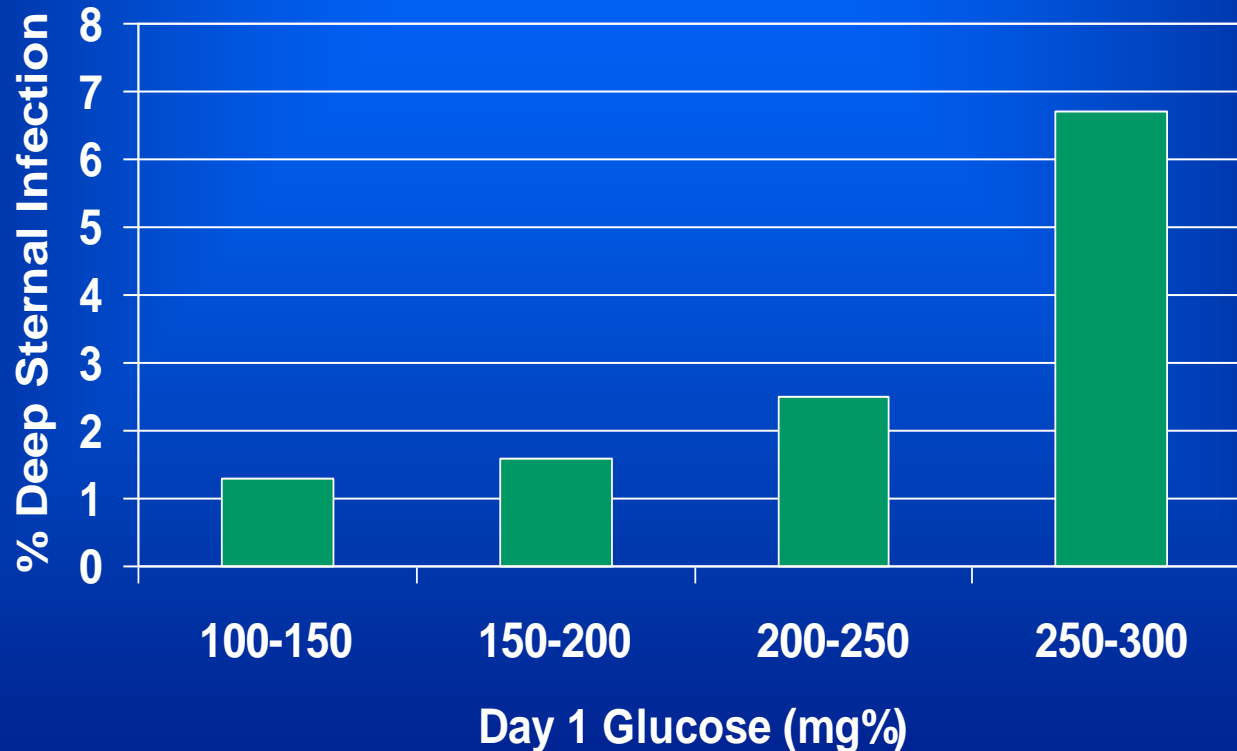
# Hyperglycemia and Risk of SSI after Cardiac Operations

- Hyperglycemia - doubled risk of SSI
- Hyperglycemic:
  - 48% of diabetics
  - 12% of nondiabetics
  - 30% of all patients
- **47% of hyperglycemic episodes were in nondiabetics**

Latham. Inf Contr Hosp Epidemiol. 2001;22:607

Dellinger. Inf Contr Hosp Epidemiol. 2001;22:604

# Deep Sternal SSI and Glucose



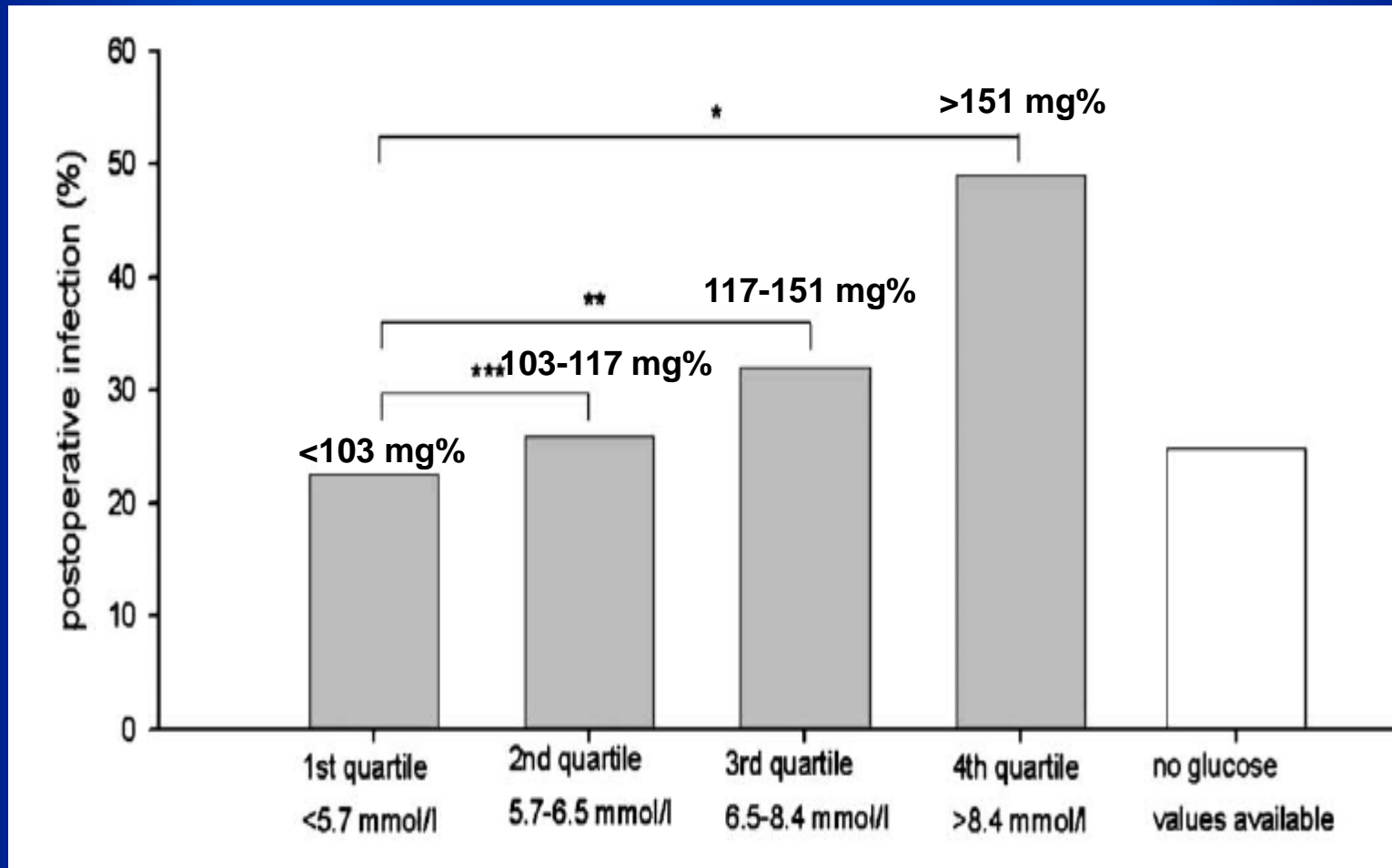
Zerr. Ann Thorac Surg 1997;63:356

**SCIP only mandates glucose control for cardiac surgery**

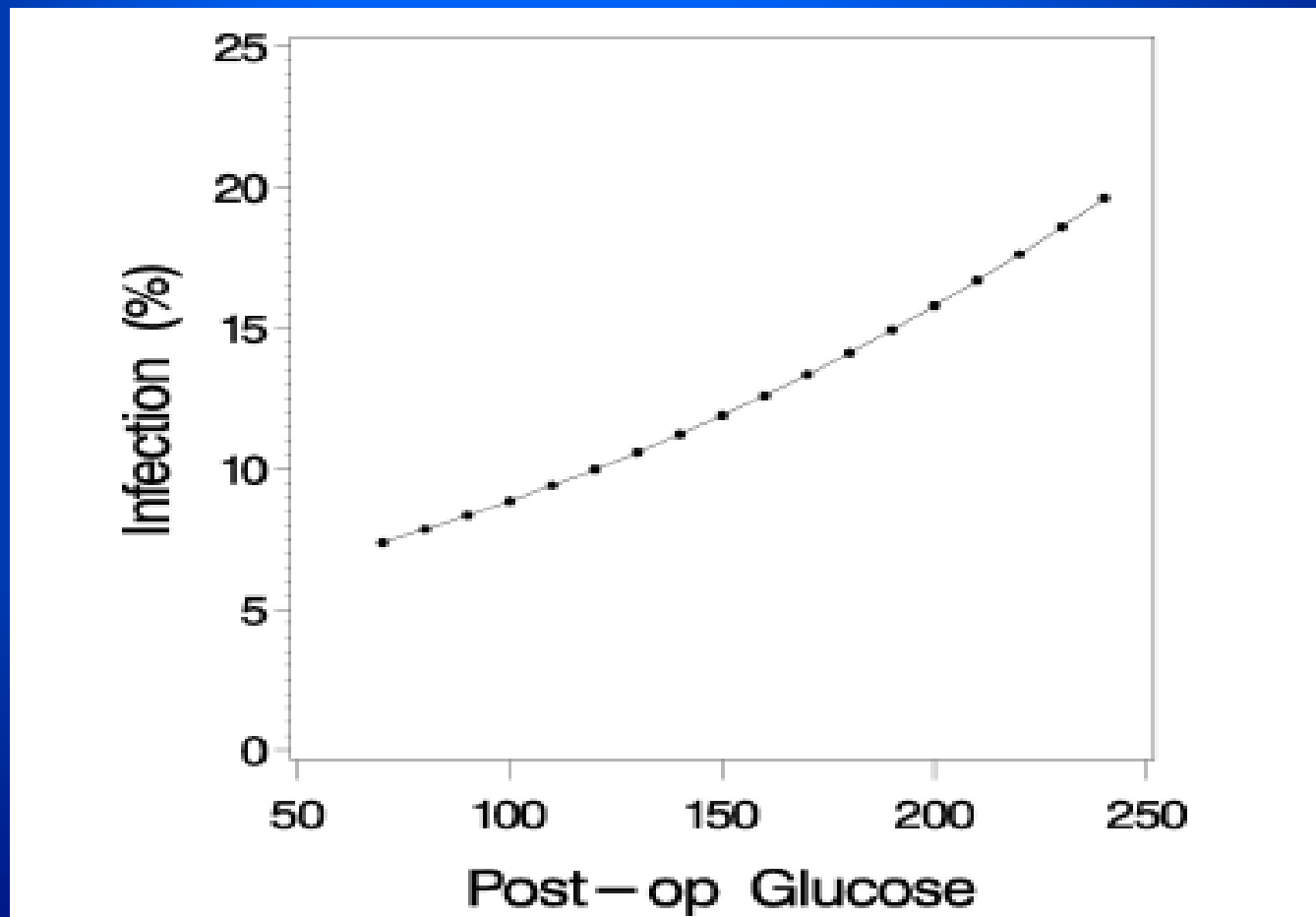
# Hyperglycemia and Infection

- Does it apply only to cardiac surgery?
- Do WBC struggling to work in syrup know whether they are in a median sternotomy or another incision?

# Early (48h) Postoperative Glucose Levels and SSI after Vascular Surgery



# Perioperative Hyperglycemia in Noncardiac Surgical Patients





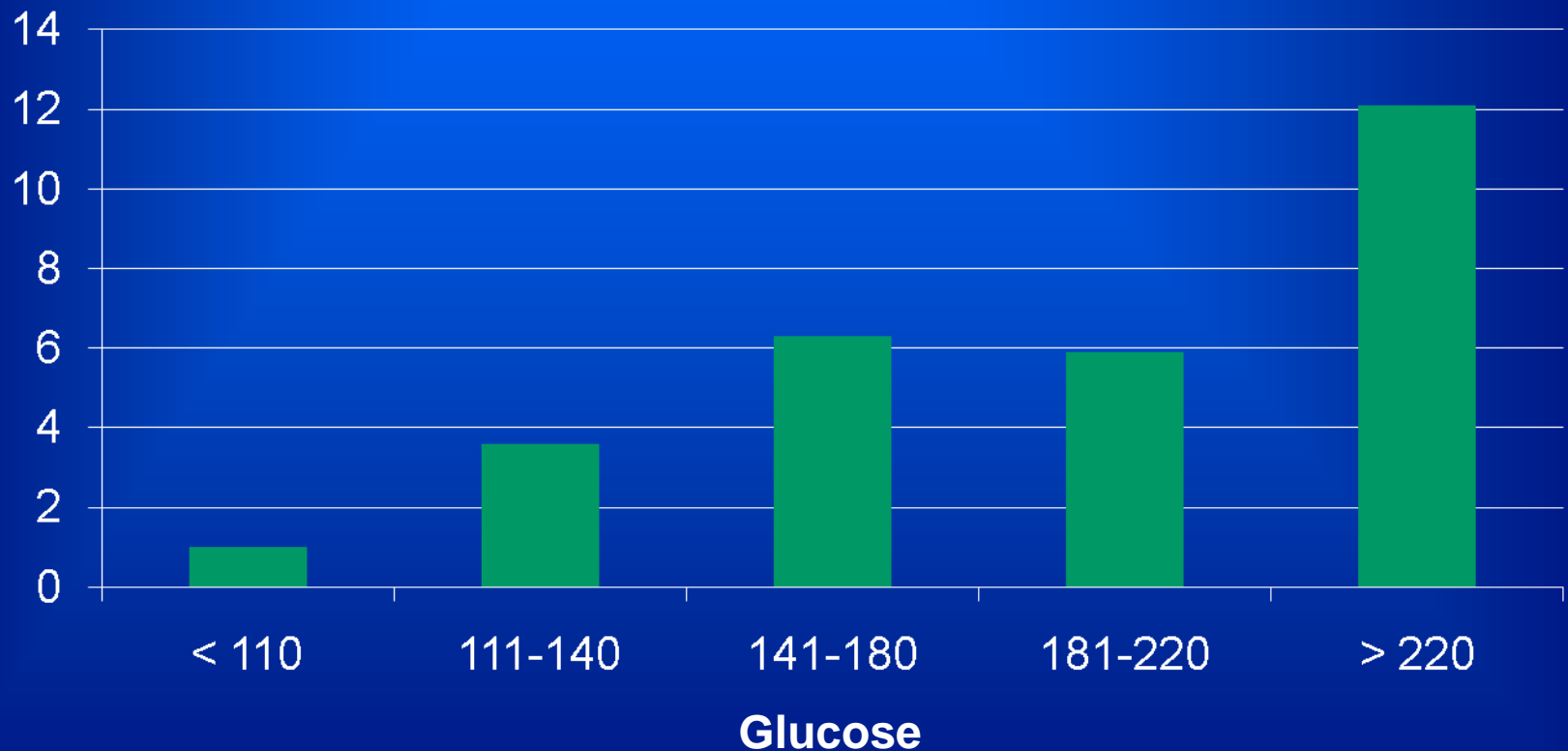
# Mastectomy, Hyperglycemia, and SSI

260 patients, 5 glucose determinations (pre-op, at anesthesia induction, intra-op, in PACU, at 24 hrs)

<u>Risk Factor</u>	<u>Odds Ratio</u>	<u>C.I.</u>
Age > 50	3.7	(1.5-9.2)
Pre-Op ChemoRads	2.8	(1.4-5.8)
Any gluc $\geq$ 150 mg%	2.9	(1.2-6.2)

# Postop Glucose (within 48h) and SSI – General Surgery

Relative Risk

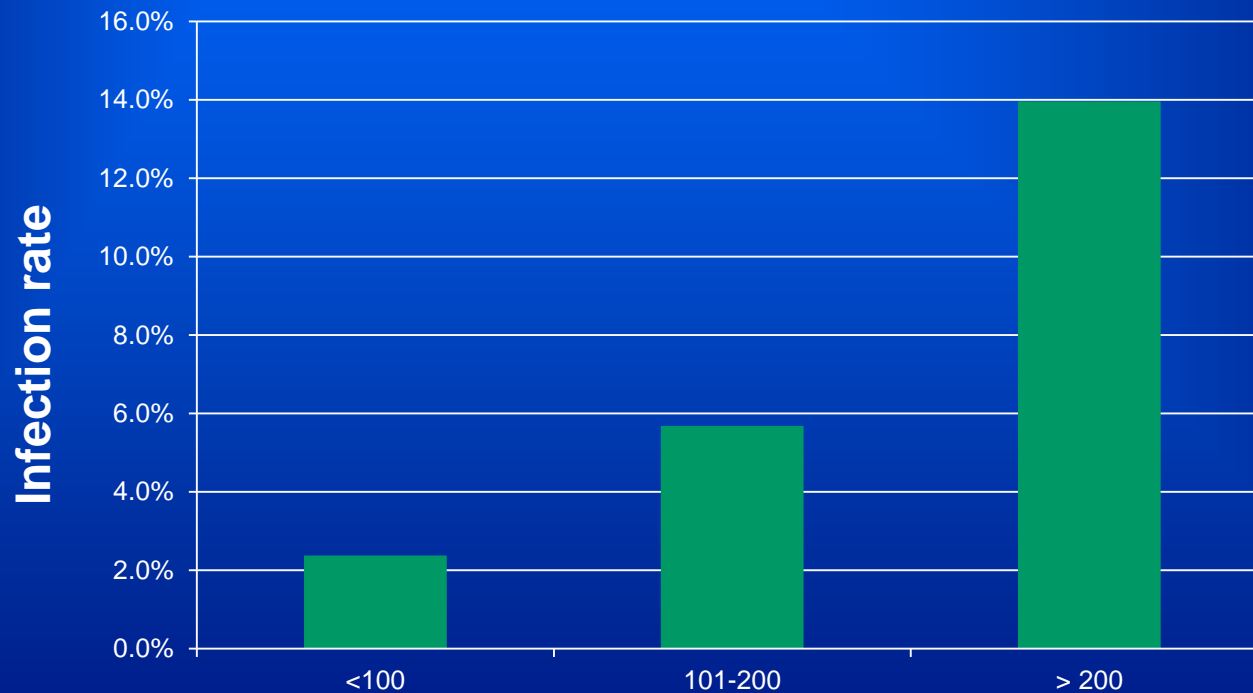


Ata. Arch Surg 2010; 145: 858-864

# Postoperative Glucose and Mortality in Noncardiac Surgery

Hyperglycemia in nondiabetic patients was more dangerous than hyperglycemia in diabetics!

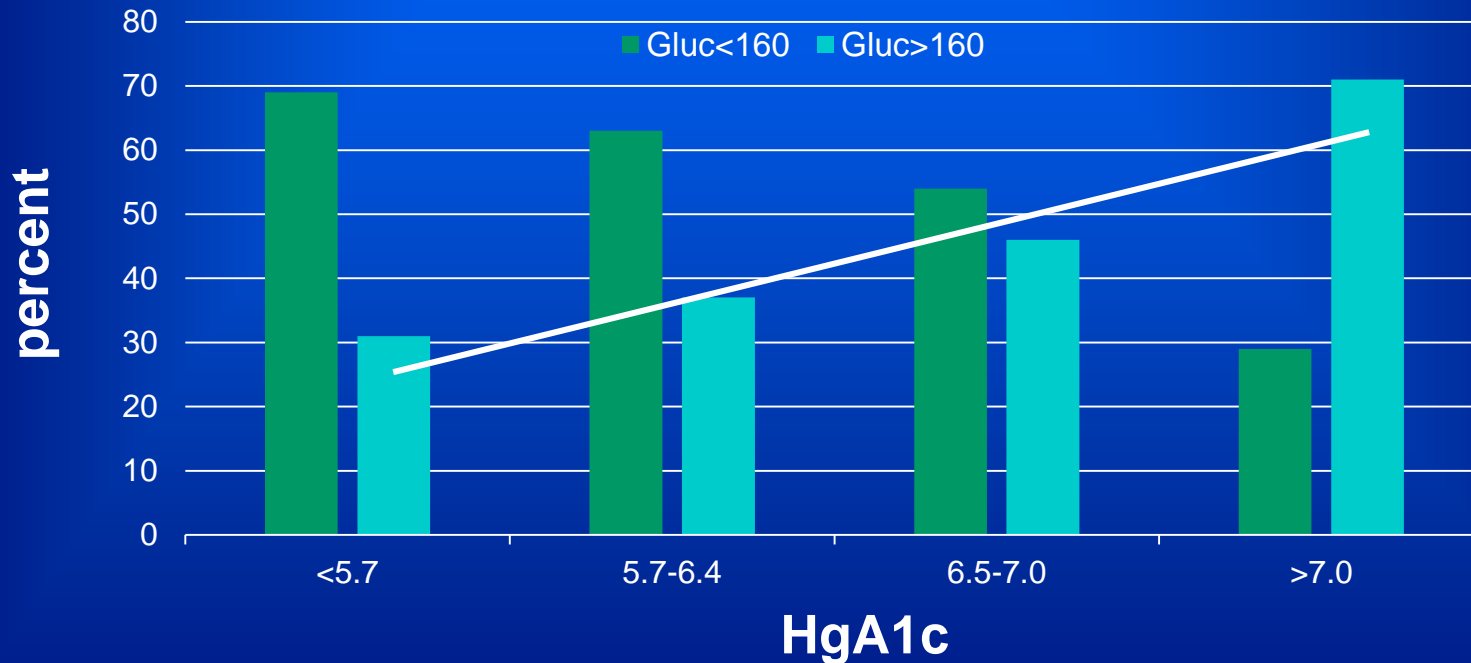
# Perioperative Hyperglycemia and Total Knee or Hip Arthroplasty Fasting Blood Glucose POD #1



Mraovic. J Diab Science & Technol 2011; 5: 412-8

# HgA1c and Postoperative Glucose – Abdominal Surgery

Relation of Preoperative A1c to Postoperative Glucose



# Glucose & Infection Risk

## Non-Cardiac Surgery & Diabetes

VASQIP – 55,408 patients

### Multivariate analysis:

- All the usual risk factors significant.
- HgbA1c **NOT** significant.
- PreOp glucose **NOT** significant.
- **PostOp glucose > 150 very significant.**

# Hgb A1c vs. Glucose as Risk Factor for SSI – Gastric Bypass

## Multivariate Analysis

Odds ratio = 1.27 for every 20 mg% increase in mean glucose level during hospitalization (p=0.008).

Mean glucose more significant than any single level above 200 Mg% or not.

Hgb A1c not significant.

# SCOAP Data on Perioperative Glucose Levels and Insulin Use

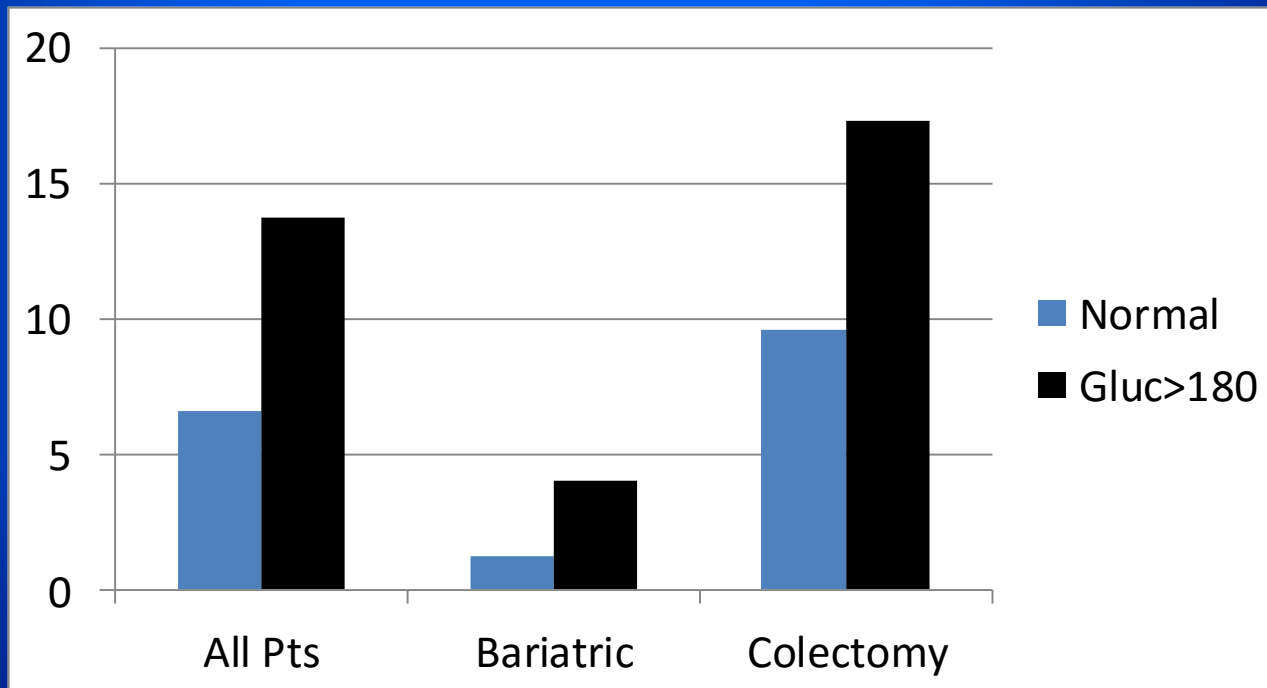
Diabetic pts	4098 (35%)
Hyperglycemic	2369 (58%)
Nondiabetic pts	7532 (65%)
Hyperglycemic	1014 (13%)

**30% of all hyperglycemic patients were not diabetic!**

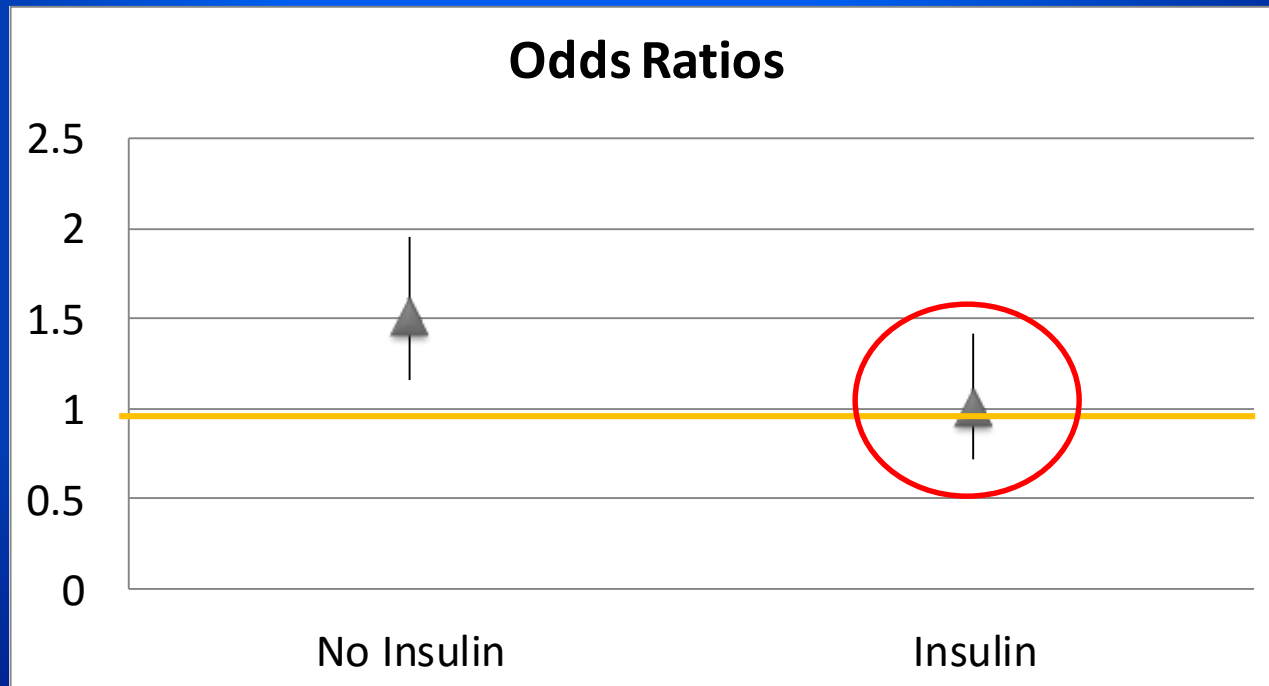


# Composite Infection

## Hyperglycemia vs No Hyperglycemia Nondiabetic Patients

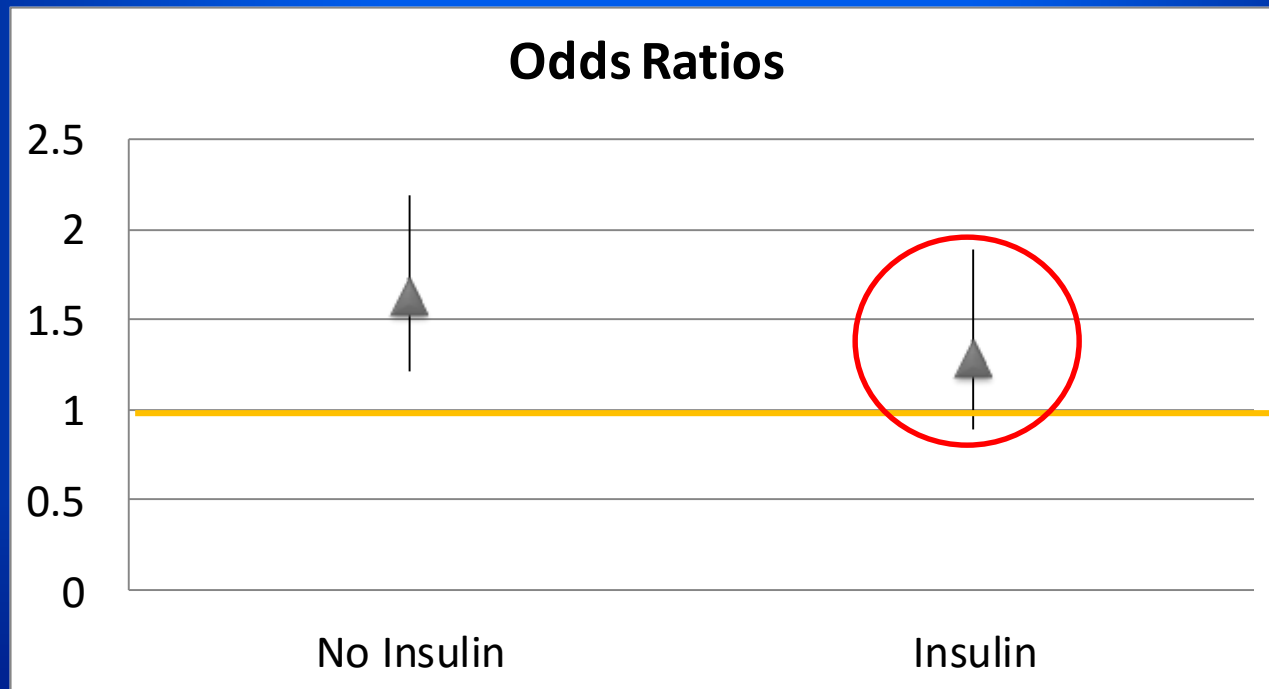


# Composite Infection in Hyperglycemic Patients With and Without Use of Insulin



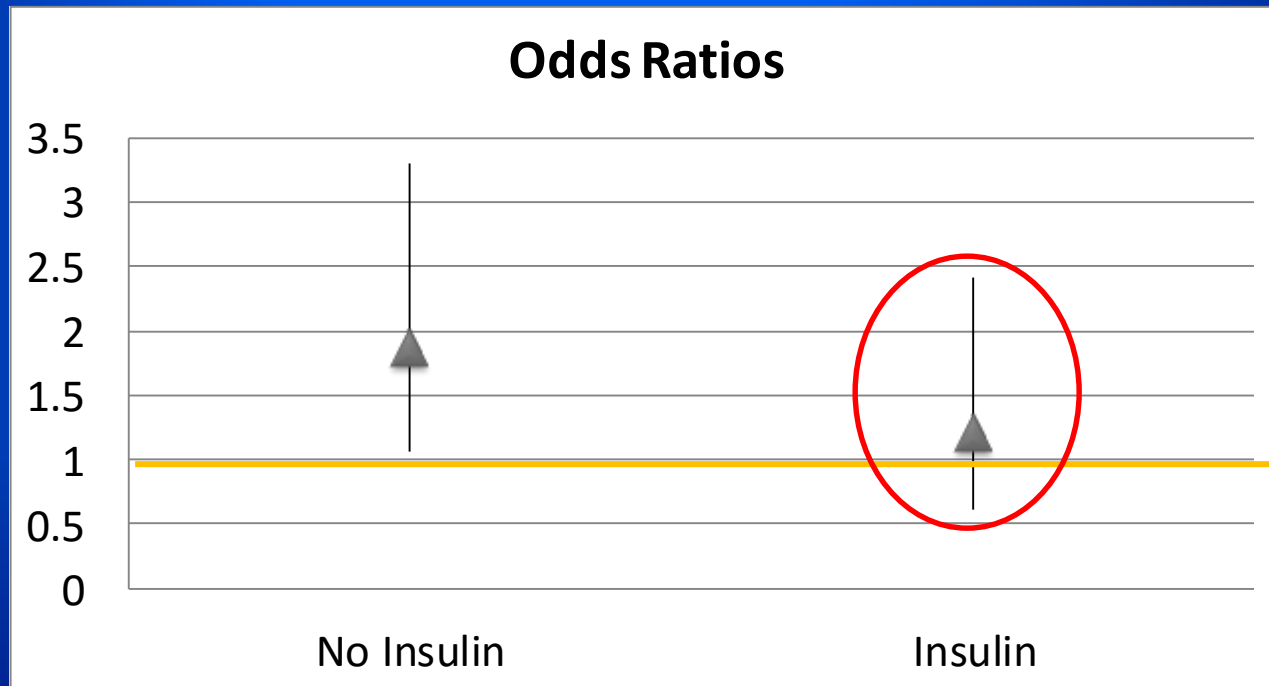
Insulin reduces risk even when glucose control is not as good as desired

# Operative Reintervention in Hyperglycemic Patients With and Without Use of Insulin



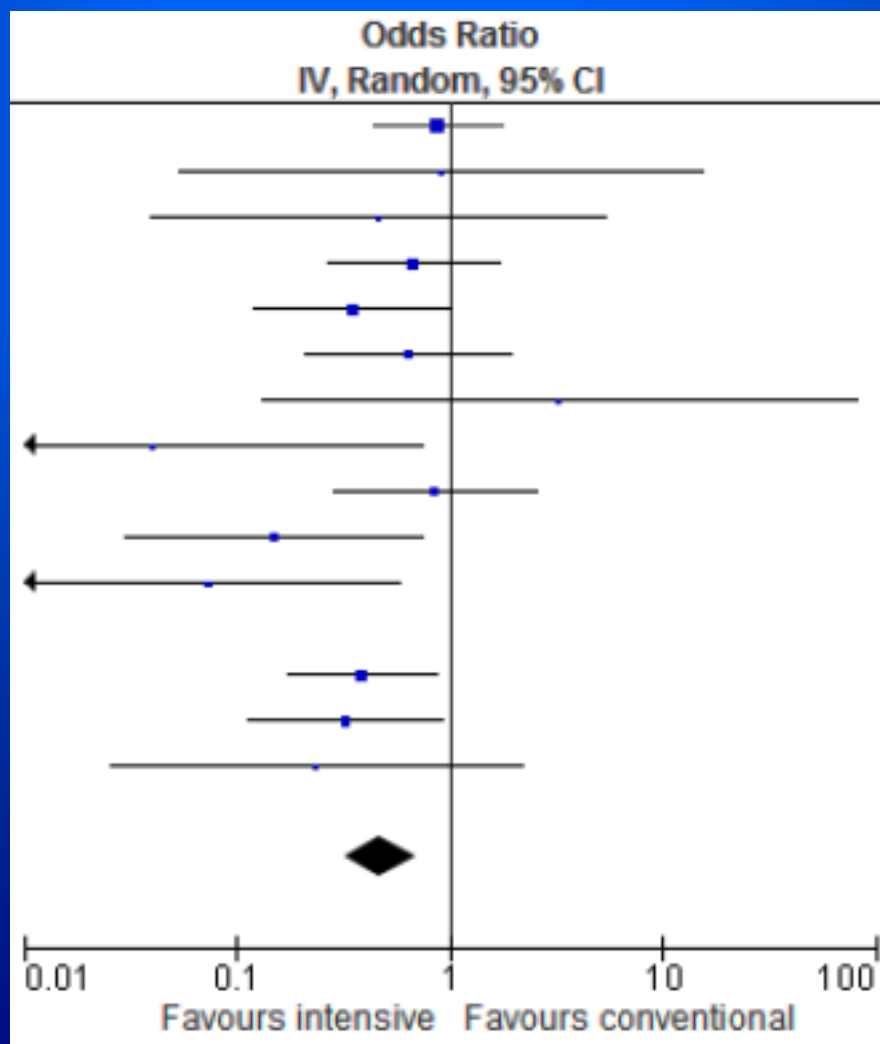
Insulin reduces risk even when glucose control is not as good as desired

# Mortality in Hyperglycemic Patients With and Without Use of Insulin



Insulin reduces risk even when glucose control is not as good as desired

# SSI with Strict vs Permissive Perioperative Glucose Control



de Vries, et al,  
mss in prep

# Glucose Control

**Proven important for SSI risk:**

**Cardiac surgery**

**General surgery**

**Colorectal surgery**

**Vascular surgery**

**Breast surgery**

**Gynecologic Oncology surgery**

**Hepato-pancreatico-biliary surgery**

**Orthopedic surgery**

**Trauma surgery**

**•Regardless of the Diagnosis of  
Diabetes  
(or not)  
Hyperglycemia Increases**

- Morbidity**
- Mortality**
- Length of Stay**

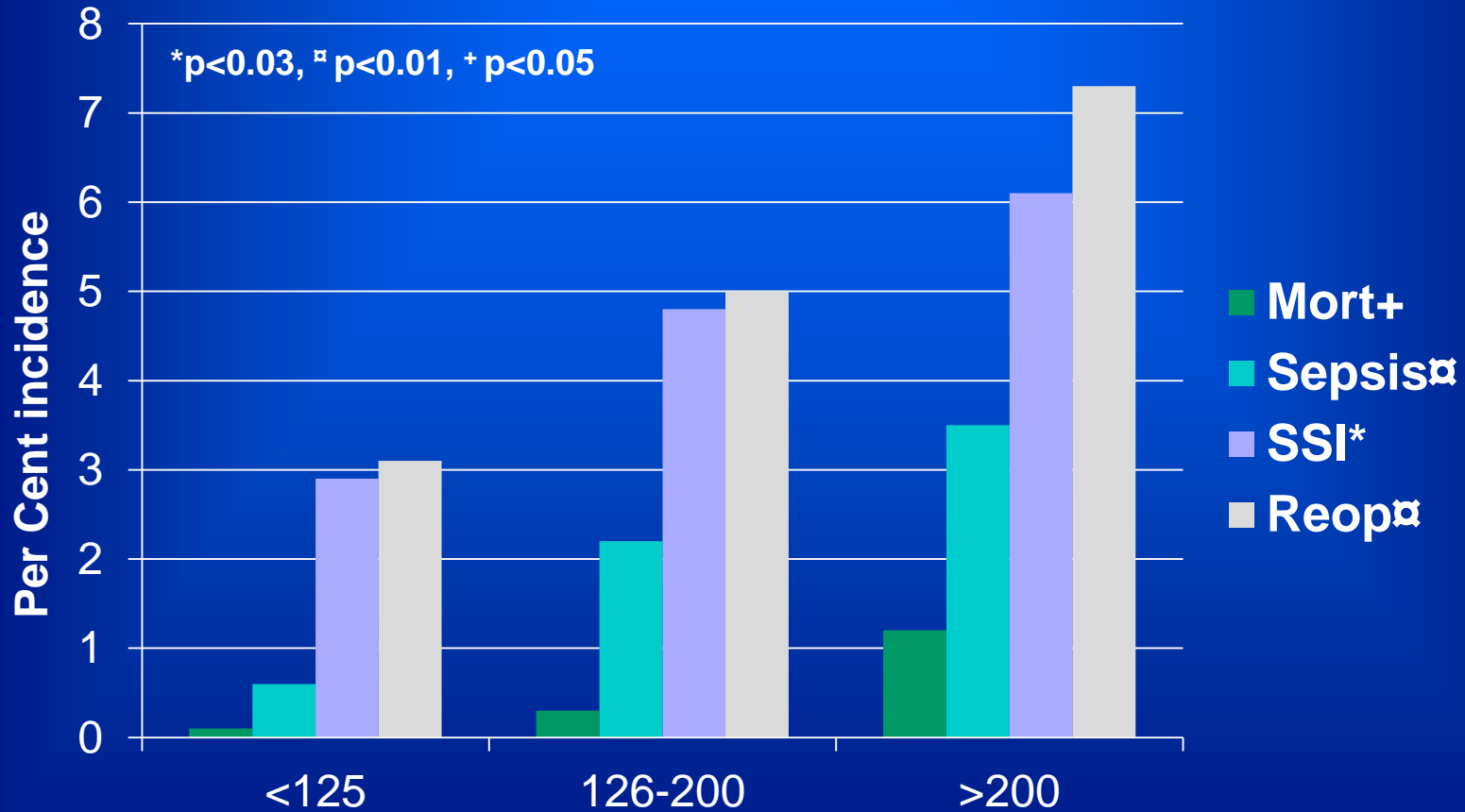
**Which Patients Are at Risk  
for Hyperglycemia?**



# Glucose in NonDiabetics having Colectomy at Cleveland Clinic

<u>Highest Gluc</u>	<u>N (%)</u>	
$\leq 125$ mg%	816 (33%)	
126-200 mg%	1289 (53%)	} 67%
200 mg%	342 (14%)	
All patients	2447 (100%)	

# Glucose in NonDiabetics having Colectomy at Cleveland Clinic

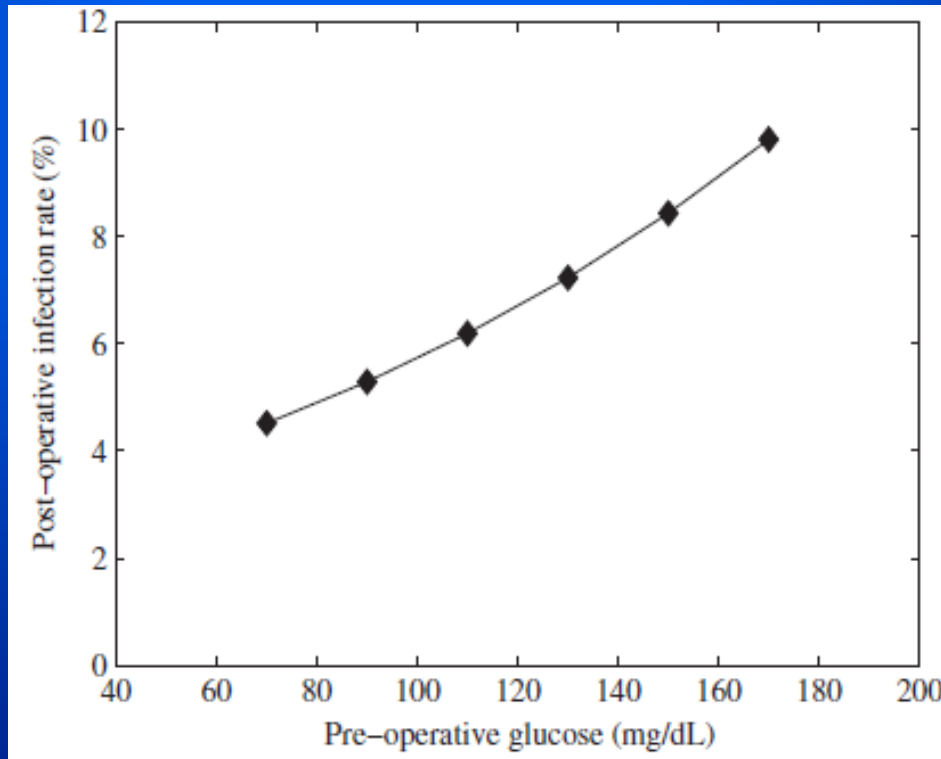


Kiran, et al. Ann Surg 2013; 258:599-605

# Preoperative Glucose as a Screening Tool for Patients Without Diabetes

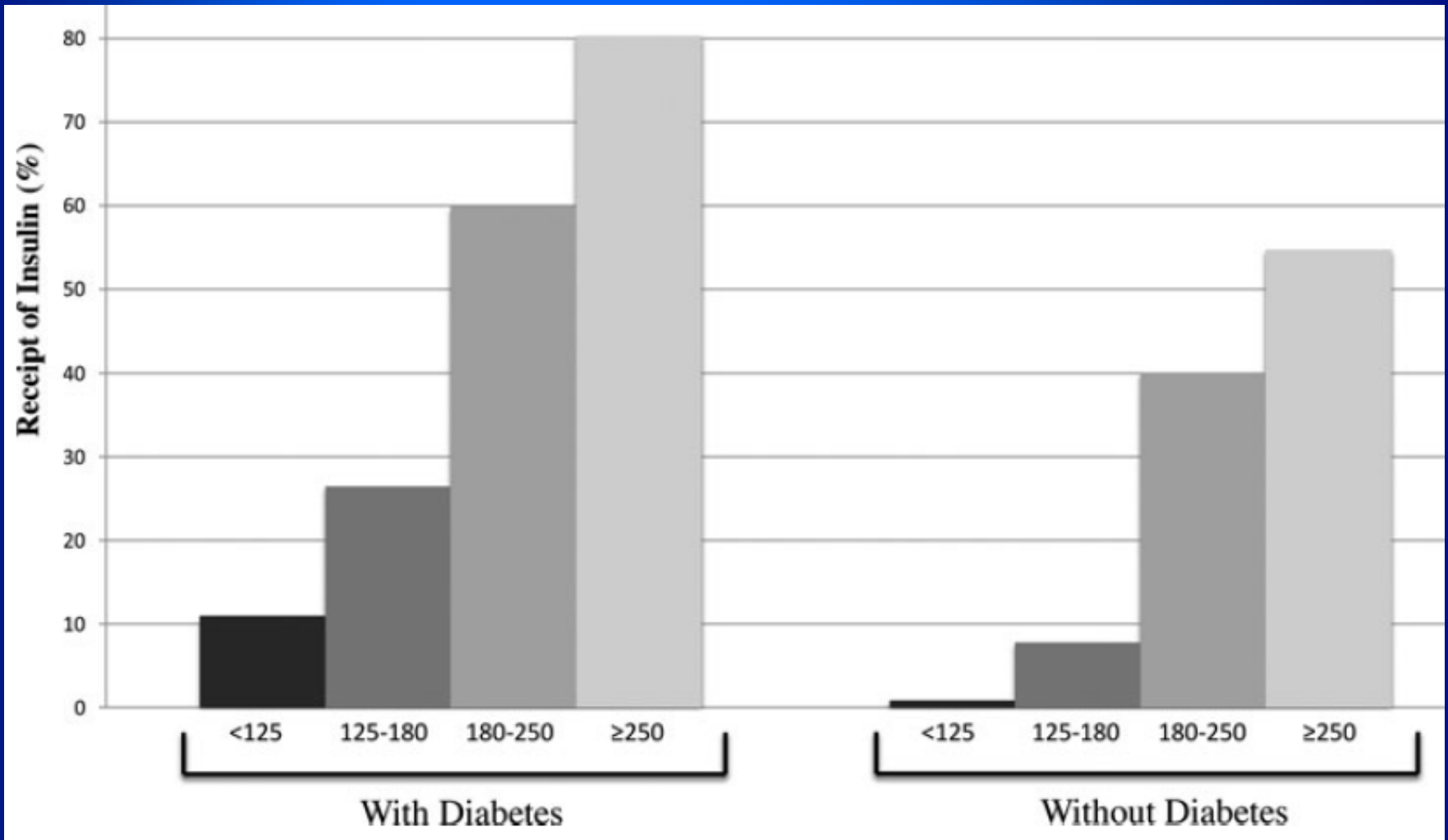
- Random glucose within 30 days of operation
  - Average 8 days before operation
  - 16% within one day and 29% within 3 days
  - 6683 patients
    - <70            384 pts
    - 70-99          4251 pts
    - 100-139       1801 pts
    - 140-179       187 pts
    - >180           60 pts
- } 31%

# Preoperative Glucose as a Screening Tool for Patients Without Diabetes

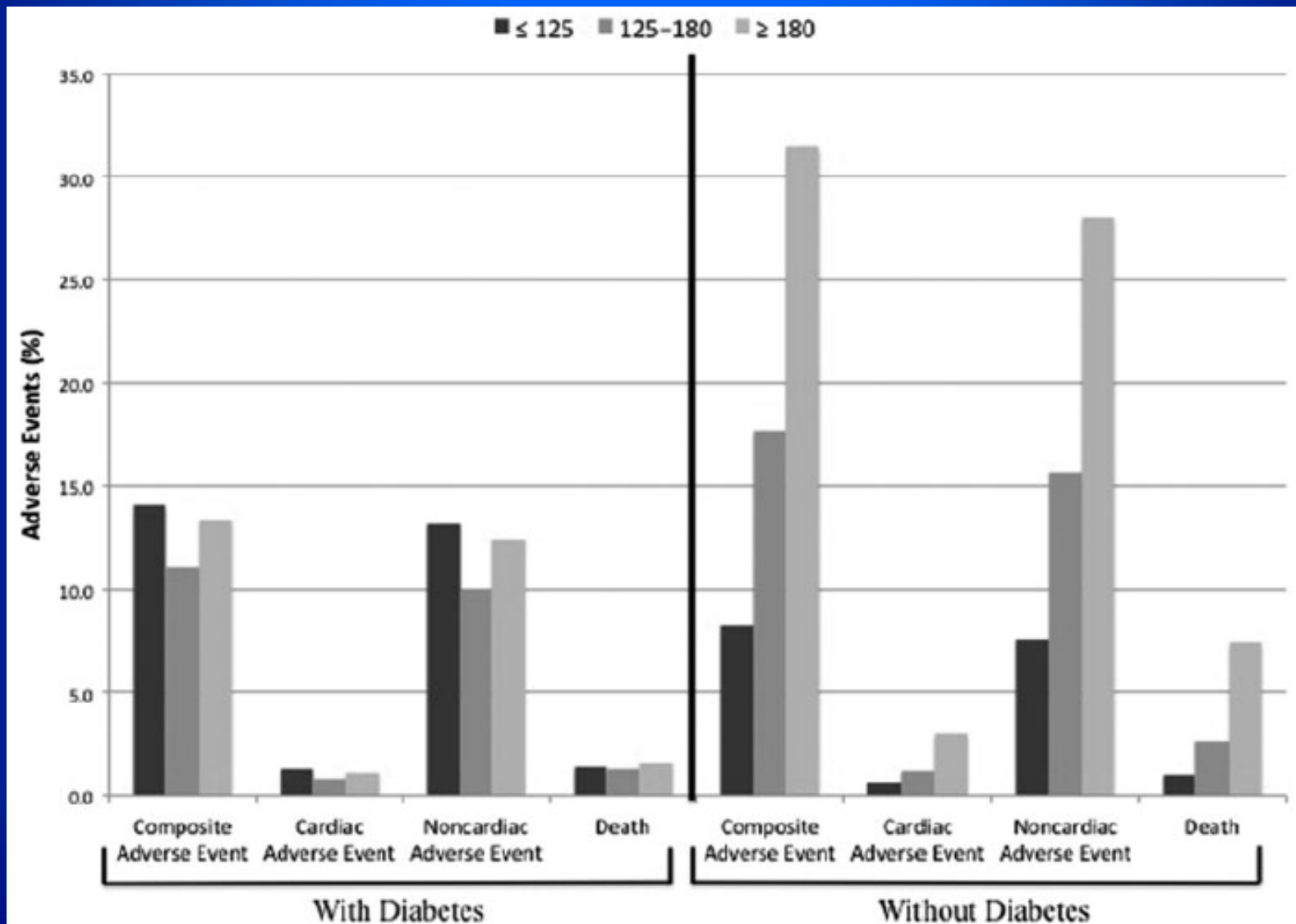


**Pre-Op Glucose vs. Post-Op Infection, adjusted for age, gender, BMI, ASA, & type of operation.**

# SCOAP – NonDiabetics Less Likely to Receive Insulin for Hyperglycemia



# SCOAP Adverse Events with Hyperglycemia – Diabetics v. NonDiabetics



# Glucose Levels & SSI

- The exact “best” level of glucose control in the perioperative period is not known.
- High glucose levels unequivocally increase the risk of SSI and other perioperative infections.
- Tight glucose control in the perioperative period is tricky.
- Hypoglycemia increases the risk of morbidity and mortality.
- When algorithms are followed at UWMC hypoglycemia is very rare.

# Perioperative Blood Glucose at UWMC – Amalga data

<b>Inpatient ops, 7/1/13 – 7/30/15</b>	<b>11,079</b>
<b>Nondiabetics among those</b>	<b>8,974 (81%)</b>
<b>Nondiabetics with gluc &gt; 140 mg%, day 0-2</b>	<b>4,834 (54%)</b>
<b>Nondiabetics with gluc &gt; 140 mg% day of op</b>	<b>2,929 (33%)</b>

Data courtesy of Ray Bunnage, Center for Clinical Excellence



# Perioperative Blood Glucose at UWMMC – Amalga + NSQIP

Cases both in Amalga and NSQIP	5,109
Cases with glucose data (pre- or intra-op)	3,044
Cases with gluc > 160 mg%	664 (22%)
Hyperglycemic cases that got insulin	560 (84%)

**I am happy to share my  
slides with anyone who  
would find them useful**

**patch@uw.edu**

# Glucose Control in the OR: Our Current State

Gail A. Van Norman MD  
Professor, Anesthesiology and Pain  
Medicine, University of Washington





For Marjorie

- OR Compliance w/established protocols
- Common mistakes/misconceptions in administering insulin and glucose
- Effectiveness of current protocols in the OR
- The Future

# Kelly study 2007

Retrospective chart review of 250 pts at UWMC\* with diabetes undergoing surgery to determine

- blood glucose levels
- compliance of anesthesia providers in treating intraoperative hyperglycemia

\*Both SQ and IV insulin regimens were in use at the time.

- < 25% of anesthesia providers used insulin in the OR
- Few patients hit target range of < 200 mg/dl
- Only 2 patients experienced hypoglycemia, defined as  $BS \leq 60$  mg/dl..... *Both patients had been treated with SQ insulin.*



# Challenges to Good OR Glucose Management

- Provider Lack of knowledge about diabetes; i.e. type I diabetics need exogenous insulin despite blood glucose levels.
- Lack of task prioritization in the OR
- POC glucose testing issues—cumbersome, takes time, not automatic like BP measurements
- Lag time between glucose measurement and treatment modification—by the time pt is treated, glucose levels are rising even farther and insulin dose may already be too low
- Lack of basic treatment technique
  - Do you flush your insulin tubing or just start insulin running?
  - Do you bolus with regular insulin prior to beginning a drip?

## (cont)

- Fear of overtreatment—e.g. hypoglycemia
- Patients are much more insulin resistant in the periop period:
  - Stress hormone release (epi, norepi, cortisol, etc)
  - Delivery of exogenous catecholamines is common (ephedrine, epi, dopamine, etc)
  - Underlying conditions (e.g. infection) leading to need for surgery predispose to insulin resistance
  - Anesthetic agents may induce insulin resistance (e.g. SEV, ISF both induce insulin resistance in pigs)—and yet may have an overall positive effect by lowering stress hormone levels.

# Compliance with Glucose Management Protocols (Nair et al, 2015\*)

- Prospective study
- Customize alert system in AIMS to nudge anesthesia providers to check a blood glucose level within ½ hour of start of surgery, and hourly thereafter
- Compliance with glucose testing and with a standard IV insulin protocol were measured before and after institution of the alert system

\* J Clin Monit Comp Nov 2015

- Compliance with glucose testing improved from 52.6% to 72.1% with the SAM alert system
- Compliance with glucose testing was much higher in cases where SAM was enabled (81%) than when the provider disabled the SAM alert (57.4%)
- However correct insulin dosing only improved from 13.5% to 24.4%--less than ¼ of patients received treatment that matched protocol
- Target glucose levels did not improve significantly

# Sathishkumar et al

## Anesthesiology July 2015

- 2341 patients, retrospective data study
- Excluded surgeries < 1 hr, ASA 5 and 6 pts
- 791 cases used Alert Watch: audiovisual alert system notifies of out of range glucose ( $\geq 200$  mg/dL) and then disappears when insulin started, reminders q 90 min.

- Hypoglycemia ( $\leq 70$  mg/dL) was no different between alert watch (AW) and controls. (approx 3-4%)
- Insulin treatment for BS  $\geq 200$  mg/dL improved from 52.7% to 62.7% with AW
- *The odds of getting a BS rechecked after initiation of insulin therapy improved from 42.3% to 51.5% with AW*

## Nair, et al.\*

- Retrospective review of electronic data on 2440 pts undergoing surgery at UWMC from 2011-2013.
  - At least one BS  $\geq 140$  during the case
  - At least one BS available postop
  - Case duration  $> 1$  hour

\*Anesth Analg Nov 23, 2015 epub ahead of print

- Intraop glucose (all patients  $\geq 140$  mg/dL)
  - 35% exceeded 180 mg/dL
  - 45% received intraop glucose management
- Postoperative glucose
  - 12 hr postop glucose  $\geq 180$  mg/dL = 50%
  - 24 hr postop glucose  $\geq 180$  mg/dL = 53%



- For every 10 mg/dL increment of glucose over 140 mg/dL, there was a mean increase in 4.7 mg/dL in the first postoperative ( $\leq 1$  hour) glucose, 2.6 mg/dL in the 12 hour postop glucose, and 2.4 mg/dL in the 24 hour postop glucose levels ( $p < 0.001$  for all)
- Effect was stronger for larger BMI, pts diagnosed with diabetes mellitus, and intraop steroid use

- Postoperative hyperglycemia ( $\geq 180$  mg/dL) was less frequent at 12 and 24 hours if intraop glucose management began at 140 mg/dL rather than 180 mg/dL (50% vs. 62% and 59% vs. 70%, respectively)
- Postop 12 and 24 hour mean glucose levels were lower by 9 and 7 mg/dL respectively if intraop insulin was initiated at 140 mg/dL compared to 180 mg/dL

# Hypoglycemia ( $\leq 60$ mg/dL)

- *No difference in postop hypoglycemia whether intraop target was 140 mg/dL or 180 mg/dL.*
- 15 cases of hypoglycemia intraop and within 1 hr of surgery (0.6% of all cases)
- No difference in hypoglycemia observed postop between pts with and without dx of diabetes
- Postop hypoglycemia occurred in 23/29 observed hypoglycemic cases within 12 hours (1% of all cases)
- Severe hypoglycemia ( $< 40$  mg/dL) was seen in 2 patients intraop, and 6 patients postop ( $8/2440 = 0.3\%$  of all cases)

# Hypoglycemia

- In all but one of the intra and immediate postop cases, hypoglycemia occurred when intraop providers *deviated from the standard insulin protocol*, including the overdosing of insulin in at least 7 cases.

(other deviations can include failure to test hourly glucose, failure to adjust insulin infusion according to protocol)

# Basic Issues

- Do all providers fill the piggyback IV tubing *and then flush 22-25 cc of insulin solution through the tubing before hooking it up.*
- Do all providers routinely hook insulin drip in the port closest to the skin?
- Should all providers routinely bolus with regular insulin before initiation the drip?
- Do all providers understand that type I diabetes **MUST** be treated with insulin even if blood glucose is **NORMAL** (i.e 60-100 mg/dL)? *Why is this true?*

# The Future

- How can we further improve compliance to glucose management protocols in the intraoperative period?
  - Improved awareness of detrimental effects of perioperative hyperglycemia
  - Continued improvement of AIMS system: better compliance with protocol will allow us to refine the protocol further
  - Improved understanding/management of diabetes by perioperative providers
  - *Continuous glucose monitoring tools are likely to help.*

# Changes to Perioperative Glucose Management

---

G. Alec Rooke, M.D., Ph.D.

rooke@uw.edu

# All Patients Get Glucose Measured

---

- POC glucose in holding
- If glucose above target range
  - ✓ 140 for UWMC, 180 for HMC
  - ✓ If patient will remain in-house after surgery, initiate insulin/glucose infusions
  - ✓ If patient expected to go home, glucose management at discretion of surgical and anesthesia teams



# Glucose Measurement in OR

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- Regardless of glucose value in holding, repeat glucose level 30-60 minutes after incision
- Initiate glucose management if necessary
- Glucose measurements every hour if insulin initiated

# Changes to Insulin Protocol in the Operating Room

---

- Non-diabetics and known diabetics treated the same
- Insulin algorithms same as for hospital
  - ✓ Includes algorithms 0.5 and 5-8
- D5 infusion at 100 ml/hr not always expected on initiation of insulin infusion

# Glucose Infusion Guidelines

---

- Patients on chronic insulin:  
initiate once glucose is below 200
- Patients not on chronic insulin:  
initiate once glucose is below 150
- Intracranial and CPB cases will be excluded

# Smart Anesthesia Monitor (SAM)

---

- Accesses and analyzes information:
  - ✓ Presence of diabetes from the anesthetic record or preop evaluation
  - ✓ Glucose values (automatically load into the anesthetic record)
  - ✓ Detects insulin and dextrose infusion rates if entered into the anesthetic record
- Provides alerts to the anesthesia team

# SAM Messages

---

- Glucose check reminder 45 minutes after incision if not already done
- Recommends an insulin infusion once glucose levels exceed target threshold
- Hourly reminders to check glucose
  - ✓ if insulin is running
  - ✓ Intraop checks show increasing values
- If glucose  $< 100$ , stop insulin and check glucose every 20 minutes

# Alerts For Glucose Infusion

---

- Patients on chronic insulin whose glucose levels fall below 200
- Patients not on chronic insulin whose glucose levels fall below 150
- Intracranial and CPB cases will be excluded

# Patients Who Should Get Insulin and Dextrose Infusions

---

- True Type 1 diabetics
- Patients with a history of DKA
- Patients taking gliflozin drugs  
(Farxiga, Invokana, Jardiance, Glyxambi)
  - ✓ Encourage urinary excretion of glucose
  - ✓ Euglycemic DKA can occur  
(presenting glucose as low as 150)

*Diabetes Care 2015;38;1687-93*

# SAM Insulin/Dextrose Infusion Alerts

---

- Evidence of “Type I DM” or “DKA” in preop note
- Gliflozin in the med list, then alert for insulin and glucose



# SAM Insulin Infusion Alerts

---

- Won't recommend specific insulin rates
- Will follow trends in glucose levels
  - ✓ Decrease of  $\geq 75$ /hour will suggest moving to a lower algorithm
  - ✓ Failure to decrease (if still above target) will suggest moving to a higher algorithm
- Caregivers are free to change algorithms as clinically indicated

# Postoperative Glucose Management

---

- Return to standard hospital protocol in the PACU
  - ✓ Glucose infusion may then be started
- Continue/discontinue protocol on the ward/ICU as per current practice
- All patients get a fasting glucose measurement on POD #1 and #2

**Thank You to the Many  
Multidisciplinary Team Members Who  
Have Worked on this Project for the  
Past 8 Months**

**Kate Curtis**

**Janet Kelly**

**Christopher Kim**

**Heather Lien**

**Diane Matsuwaka**

**Alec Rooke**

**Solina Tith**

**Ray Bunnage**

**Lucas Thornblade**

**Benjamin Anderson**

**Cindy Sayre**

**Diana Villaflor-Camagong**

**David Flum**

**Gail Van Norman**

**Irl Hirsch**

**Jing Chao**

**Joan DiGiacomo**

**John Lang**

**Marcelo Hinojosa**

**Rachel Thompson**

**Lisa Goben**

**Patchen Dellinger**