Perioperative Glycemic Control for all Surgical Patients?

Jude Erric L. Cinco, MD, FPCP, FPCC
Cardiologist-Intensivist
Asst. Prof. Ateneo School of Medicine and Public Health

- None to disclose for this topic

Outline

- The problem with hyperglycemia
- Glycemic control in ICU
- Glycemic control in Surgery

The Problem with Hyperglycemia

- Diabetes mellitus is the most common endocrine disorder encountered in the perioperative period.
- The endocrine response to the stresses of surgery predisposes to hyperglycemia.

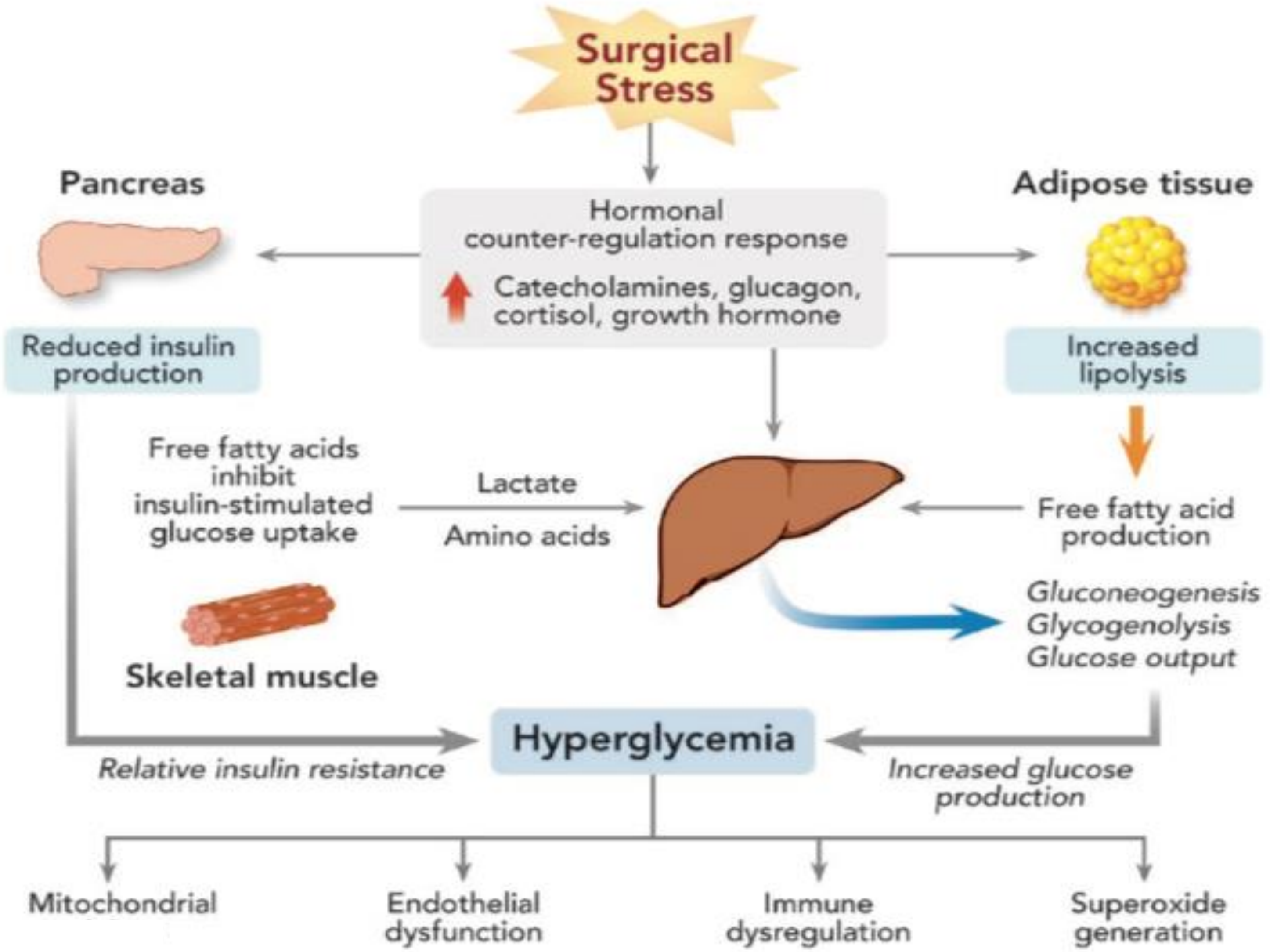


Fig. 1. The surgical stress response.

Elizabeth W. Duggan, MD, et al. Perioperative Hyperglycemia Management An Update. Anesthesiology 2017; 126:547–60

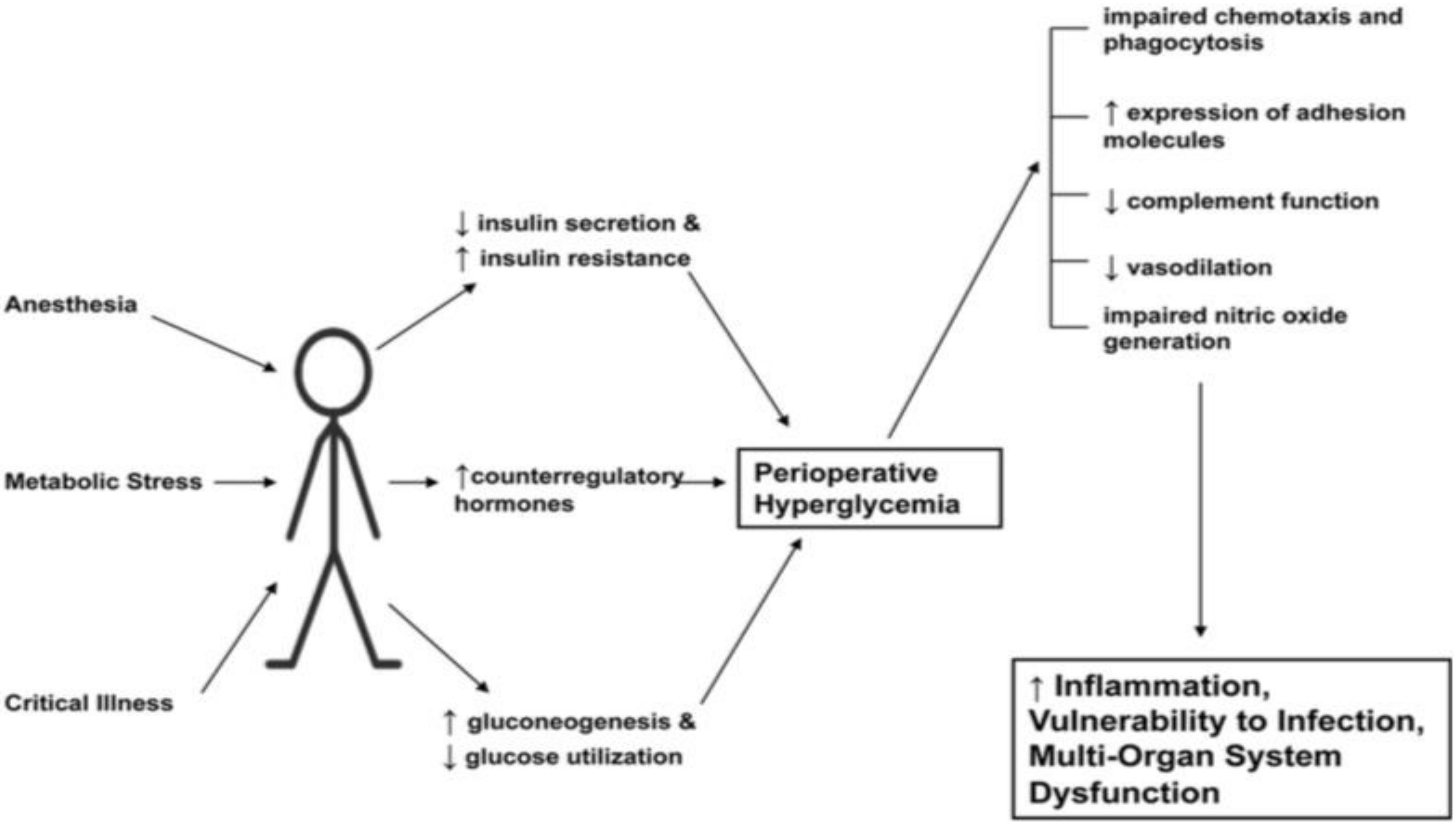


Fig. 1. Pathophysiology of hyperglycemia. Anesthesia, metabolic stress, and critical illness lead to metabolic derangements, resulting in hyperglycemia. Hyperglycemia is associated with increased inflammation, susceptibility to infection, and organ dysfunction.

Angela K. M. Lipshutz, MD, MPH et al. Perioperative Glycemic Control. Anesthesiology 2009; 110:408 –21 meeting the gaps in critical care

Glycemic Control in ICU

http://aidenslegacy.org/about.html

DPI CME TRAINING PROGRAM TRADEMARK

The New England Journal of Medicine

Copyright © 2001 by the Massachusetts Medical Society

VOLUME 345 | NOVEMBER 8, 2001 | NUMBER 19

INTENSIVE INSULIN THERAPY IN CRITICALLY ILL PATIENTS

GREET VAN DEN BERGHE, M.D., PH.D., PIETER WOUTERS, M.SC., FRANK WEEKERS, M.D., CHARLES VERWAEST, M.D., FRANS BRUYNINCKX, M.D., MIET SCHETZ, M.D., PH.D., DIRK VLASSELAERS, M.D., PATRICK FERDINANDE, M.D., PH.D., PETER LAUWERS, M.D., AND ROGER BOUILLON, M.D., PH.D.

N Engl J Med 2001;345:1359-67

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 | MARCH 26, 2009 | VOL. 360 NO. 13

Intensive versus Conventional Glucose Control in Critically Ill Patients

The NICE-SUGAR Study Investigators*

N Engl J Med 2009;360:1283-97

http://aidenslegacy.org/about.html

Glycemic Control in ICU: Network Meta-Analysis #1

- Four different target blood glucose levels
  - <110 mg/dL
  - 110–144 mg/dL
  - 144–180 mg/dL
  - >180 mg/dL

Yatabe T, Inoue S, Sakaguchi M, et al. The optimal target for acute glycemic control in critically ill patients: a network meta-analysis. Care Med 2017;43:16–28

http://aidenslegacy.org/about.html

Glycemic Control in ICU: Network Meta-Analysis #1

- 35 RCT's, N = 18,098 patients.
- No significant differences in the risk of mortality and infection.
- <110 and 110–144 mg/dL had 4x - 9x increase in the risk of hypoglycemia compared with 144–180 and >180 mg/dL.

Yatabe T, Inoue S, Sakaguchi M, et al. The optimal target for acute glycemic control in critically ill patients: a network meta-analysis. ... Care Med 2017

http://aidenslegacy.org/about.html

Glycemic Control in ICU: Network Meta-Analysis #2

- Four glycemic control groups:
  - 4.4 < 6.1 mmol/l
  - 6.1 < 7.8 mmol/l
  - 7.8 < 10.0 mmol/l
  - 10.0 to < 12.2 mmol/l

Yamada, T., Shojima, N., Noma, H. et al. Glycemic control, mortality, and hypoglycemia in critically ill patients: a systematic review and network meta-

http://aidenslegacy.org/about.html

Glycemic Control in ICU: Network Meta-Analysis #2

- Thirty-six randomized trials (17,996 patients):
- No differences in mortality
- Hierarchy for avoiding death (highest to lowest rank): mild control, tight control, and very mild control.

http://aidenslegacy.org/about.html

Yamada, T., Shojima, N., Noma, H. et al. Glycemic control, mortality, and hypoglycemia in critically ill patients: a systematic review and network meta-

Glycemic Control in ICU: Network Meta-Analysis #2

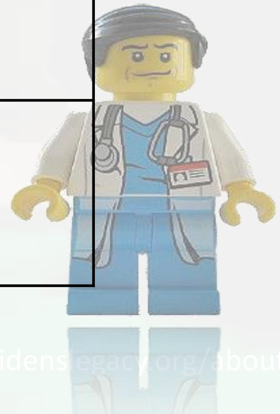
- Severe hypoglycemia (<2.2 mmol/l) was more frequent with tight control than very mild control [***RR 5.49*** (3.22–9.38), p < 0.001] or mild control [RR 4.47 (2.5–8.03), p < 0.001].

http://aidenslegacy.org/about.html

Yamada, T., Shojima, N., Noma, H. et al. Glycemic control, mortality, and hypoglycemia in critically ill patients: a systematic review and network meta-

Glycemic Control in ICU:

Surviving Sepsis Campaign	< 150
American Heart Association	< 140
European Society of Cardiology	140-180
American Diabetes Association	140-180
American College of Physicians	140-180



http://aidenslegacy.org/about.html

Glycemic Control in Surgery

http://aidenslegacy.org/about.html

http://aidenslegacy.org/about.html

The Society of Thoracic Surgeons Practice Guideline Series: Blood Glucose Management During Adult Cardiac Surgery

Harold L. Lazar, MD, Marie McDonnell, MD, Stuart R. Chipkin, MD, Anthony P. Furnary, MD, Richard M. Engelman, MD, Archana R. Sadhu, MD, Charles R. Bridges, MD, ScD, Constance K. Haan, MD, MS, Rolf Svedjeholm, MD, PhD, Heinrich Taegtmeyer, MD, DPhil, and Richard J. Shemin, MD

Department of Cardiothoracic Surgery and Division of Endocrinology, the Boston Medical Center, Boston, The School of Public Health and Health Sciences, The University of Massachusetts, Amherst, Massachusetts; The Starr-Wood Cardiac Group, Portland, Oregon; The Baystate Medical Center, Springfield, Massachusetts; Division of Endocrinology, Ronald Regan Medical Center, David Geffen School of Medicine, Los Angeles, California; Division of Cardiovascular Surgery, University of Pennsylvania Medical Center, Philadelphia, Pennsylvania; University of Florida College of Medicine, Jacksonville, Florida; Department of Cardiothoracic Surgery, University Hospital, Linkoping, Sweden; Division of Cardiology, The University of Texas School of Medicine, Houston, Texas; and The Division of Cardiothoracic Surgery, Ronald Regan Medical Center, David Geffen School of Medicine, Los Angeles, California

Perioperative Glycemic Control in Cardiac Surgery

- In 6280 patients, higher glucose levels during surgery were found to be an independent predictor of mortality in patients with and without diabetes.

http://aidenslegacy.org/about.html

Perioperative Glycemic Control in Cardiac Surgery

- **Preoperative:**
  - in 1,375 CABG patients, those with elevated fasting blood glucose had a 1-year mortality that was twice as great as patients with normal fasting values and equal to that of patients who were suspected, or known to have diabetes mellitus.

Perioperative Glycemic Control in Cardiac Surgery

- **Intraoperative:**
  - In 409 patients hyperglycemia was an independent risk factor for perioperative complications, including death.

http://aidenslegacy.org/about.html

Perioperative Glycemic Control in Cardiac Surgery

- **Post- operative:**
  - In 200 (291) patients, serum glucose level (>250 mg/dL) was associated with a 10-fold increase in complications.

http://aidenslegacy.org/about.html

Perioperative Glycemic Control in Cardiac Surgery

- Glycemic Control (>180 mg/dL) in patients with diabetes during cardiac surgery:
  - Reduces mortality
  - Reduces morbidity
  - Lowers the incidence of wound infections
  - Reduces hospital length of stay
  - Enhances long-term survival

http://aidenslegacy.org/about.html

Perioperative Glycemic Control in Cardiac Surgery

- Intraoperative glycemic control using intravenous insulin infusions is not necessary in cardiac surgery patients without diabetes provided that glucose values remain >180 mg/dL

http://aidenslegacy.org/about.html

Haga *et al. Journal of Cardiothoracic Surgery* 2011, **6**:3
http://www.cardiothoracicsurgery.org/content/6/1/3

JOURNAL OF CARDIOTHORACIC SURGERY

RESEARCH ARTICLE — Open Access

The effect of tight glycaemic control, during and after cardiac surgery, on patient mortality and morbidity: A systematic review and meta-analysis

Kristin K Haga[1*], Katie L McClymont[1], Scott Clarke[1], Rebecca S Grounds[1], Ka Ying B Ng[1], Daniel W Glyde[1], Robert J Loveless[1], Gordon H Carter[1], R Peter Alston[2]

Haga et al. Journal of Cardiothoracic Surgery 2011, 6:3

http://aidenslegacy.org/about.html

Study or Subgroup	Tight Glycaemic Control Events	Tight Glycaemic Control Total	Normal Glycaemic Control Events	Normal Glycaemic Control Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Groban 2002	3	188	0	193	1.4%	7.30 [0.37, 142.33]
Ingels 2006	16	477	37	493	98.6%	0.43 [0.23, 0.78]
Lazar 2004	0	72	0	69		Not estimable
Total (95% CI)		**665**		**686**	**100.0%**	**0.52 [0.30, 0.91]**
Total events	19		37			

Heterogeneity: Chi² = 3.45, df = 1 (P = 0.06); I² = 71%
Test for overall effect: Z = 2.29 (P = 0.02)

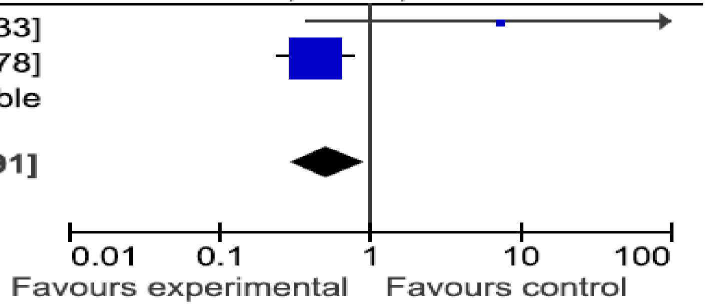


Figure 2 Results of the meta-analysis performed on the incidence of early mortality, following cardiac surgery, for patients with and without tight glycaemic control. This figure illustrates the forest plot created as a result of the meta-analysis for early mortality data. "Early mortality" was defined as death in CCU or within 30 days. Only three of the seven studies presented useable data and were included in the analysis. Tight glycaemic control peri- and post-operatively significantly reduced early mortality as compared to normal glycaemic control (p = 0.02).

Haga et al. Journal of Cardiothoracic Surgery 2011, 6:3

http://aidenslegacy.org/about.html

Study or Subgroup	Tight Control Events	Tight Control Total	Normal Control Events	Normal Control Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Chaney 1999	4	10	2	10	1.0%	2.67 [0.36, 19.71]
Gandhi 2007	54	185	59	186	35.1%	0.89 [0.57, 1.38]
Groban 2002	60	188	68	193	38.4%	0.86 [0.56, 1.32]
Koskenkari	12	20	14	20	4.7%	0.64 [0.17, 2.38]
Lazar 2004	12	72	29	69	20.8%	0.28 [0.13, 0.60]
Total (95% CI)		**475**		**478**	**100.0%**	**0.76 [0.58, 0.99]**
Total events	142		172			

Heterogeneity: Chi² = 8.82, df = 4 (P = 0.07); I² = 55%
Test for overall effect: Z = 2.00 (P = 0.05)

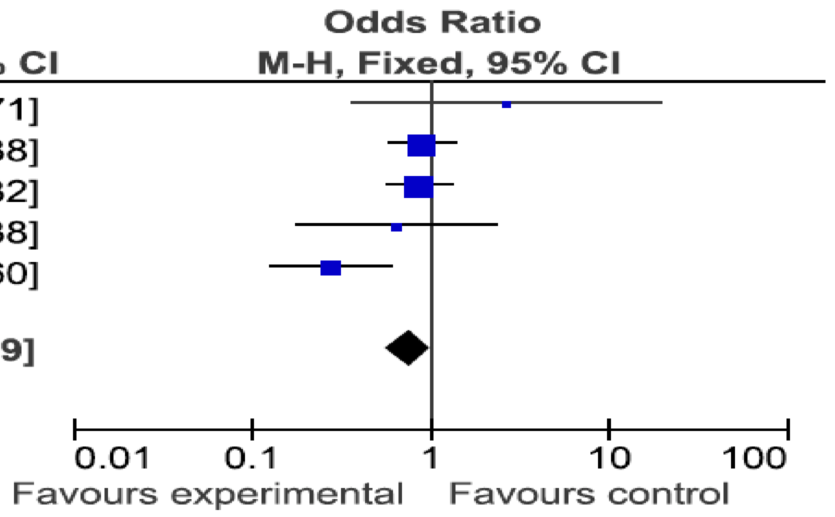


Figure 3 Results of the meta-analysis on the incidence of atrial fibrillation following cardiac surgery, for patients with and without tight glycaemic control. This figure illustrates the forest plot created as a result of the meta-analysis performed on the incidence of atrial fibrillation (AF) following cardiac surgery for the tight and normal glycaemic control groups. As can be seen, tight glycaemic control demonstrated a borderline significant reduction in the incidence of AF following cardiac surgery (p = 0.05). Only one study, Chaney et al reported a higher incidence of AF in patients in the tight glycaemic control group, however their overall patient numbers was extremely small (n = 20).

PHARMA INTERNATIONAL INC.

meeting the gaps in critical care

Study or Subgroup	Tight Glycaemic Control Mean	SD	Total	Normal Glycaemic Control Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Hoedemaekers 2005	0.921	0.075	10	0.85	0.104	10	10.5%	0.07 [-0.01, 0.15]
Koskenkari	3.2	4.7	20	2	1.2	20	0.0%	1.20 [-0.93, 3.33]
Lazar 2004	0.721	0.042	72	1.37	0.108	69	89.5%	-0.65 [-0.68, -0.62]
Total (95% CI)			**102**			**99**	**100.0%**	**-0.57 [-0.60, -0.55]**

Heterogeneity: Chi² = 284.77, df = 2 (P < 0.00001); I² = 99%

Test for overall effect: Z = 43.54 (P < 0.00001)

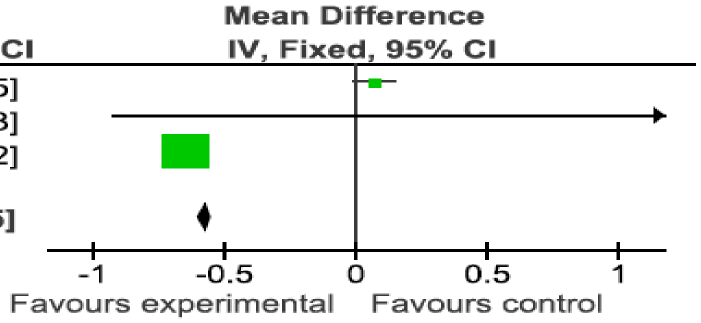


Figure 4 Results of the meta-analysis conducted on the time spent in CCU/ICU, for patients with and without tight glycaemic control, following cardiac surgery. This figure illustrates the forest plot created from the meta-analysis of total time spent in CCU or ICU following cardiac surgery, for those patients with and without tight glycaemic control. Although the results suggest that patients who were randomised to the tight glycaemic control group spent significantly less time in CCU/ICU (p < 0.00001), the significant heterogeneity (99%) of this sample makes it difficult to interpret these results. The data are significantly weighted by one study, the Lazar (2004) study, and the times spent in CCU/ICU vary dramatically between groups.

ICU FORUM
DPI CME TRAINING PROGRAM TRADEMARK

Haga et al. Journal of Cardiothoracic Surgery 2011, 6:3

http://aidenslegacy.org/about.html

PHARMA INTERNATIONAL INC.

meeting the gaps in critical care

Study or Subgroup	Tight Glycaemic Control Mean	SD	Total	Normal Glycaemic Control Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Koskenkari	11.4	20.1	20	12.9	14.2	20	0.0%	-1.50 [-12.29, 9.29]
Hoedemaekers 2005	11.2	6.6	10	9.8	4.6	10	0.1%	1.40 [-3.59, 6.39]
Groban 2002	31	4	188	32	4	193	3.7%	-1.00 [-1.80, -0.20]
Lazar 2004	6.9	0.3	72	10.7	0.6	69	96.2%	-3.80 [-3.96, -3.64]
Total (95% CI)			**290**			**292**	**100.0%**	**-3.69 [-3.85, -3.54]**

Heterogeneity: $Chi^2 = 49.10$, df = 3 ($P < 0.00001$); $I^2 = 94\%$

Test for overall effect: $Z = 46.80$ ($P < 0.00001$)

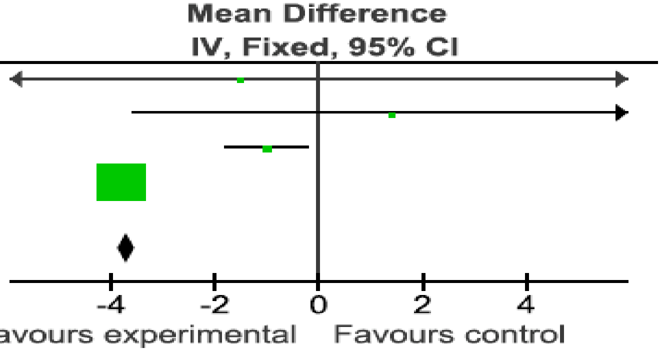


Figure 5 Results of the meta-analysis conducted on the time spent on mechanical ventilation, following cardiac surgery, for patients with and without tight glycaemic control. This figure illustrates the forest plot created from the meta-analysis of the time spent on mechanical ventilation, following cardiac surgery, for patients with and without tight glycaemic control. The results of this analysis suggest that patients who experienced tight glycaemic control peri and/or post-operatively spent significantly less time on mechanical ventilation ($p < 0.00001$). However, the results are heavily weighted by the Lazar (2004) study due to the wide ranges of time and large standard deviations in the other four studies.

ICU FORUM

DPI CME TRAINING PROGRAM TRADEMARK

Journal of Cardiothoracic Surgery 2011, 6:3

http://aidenslegacy.org/about.html

Study or Subgroup	Tight Glycaemic control Events	Tight Glycaemic control Total	Normal Glycaemic control Events	Normal Glycaemic control Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Groban 2002	3	188	2	193	5.4%	1.55 [0.26, 9.37]
Koskenkari	3	20	12	20	28.4%	0.12 [0.03, 0.54]
Lazar 2004	10	72	27	69	66.2%	0.25 [0.11, 0.57]
Total (95% CI)		**280**		**282**	**100.0%**	**0.28 [0.15, 0.54]**
Total events	16		41			

Heterogeneity: Chi² = 4.79, df = 2 (P = 0.09); I² = 58%

Test for overall effect: Z = 3.83 (P = 0.0001)

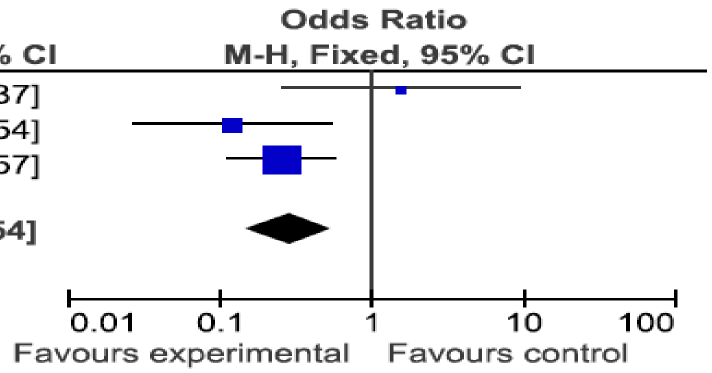


Figure 6 Results of the meta-analysis conducted on the need for epicardial pacing, following cardiac surgery, in patients with and without tight glycaemic control. This figure illustrates the forest plot produced as a result of the meta-analysis on the need for epicardial pacing in patients with and without tight glycaemic control. As can be seen in the figure, those patients with tight control experienced less need for epicardial pacing (p = 0.0001).

Haga et al. Journal of Cardiothoracic Surgery 2011, 6:3

http://aidenslegacy.org/about.html

- Results: N= 7 RCT’s
- Tight glycaemic control reduced:
- early mortality (death in ICU) (OR 0.52 [95% CI 0.30, 0.91]);
- post-surgical atrial fibrillation (odds ratio (OR 0.76 [95%CI 0.58, 0.99]);
- the use of epicardial pacing (OR 0.28 [95%CI 0.15, 0.54]);
- the duration of mechanical ventilation (mean difference (MD) -3.69 [95% CI -3.85, -3.54])
- length of stay in the intensive care unit (ICU) (MD -0.57 [95%CI -0.60, -

Journal of Cardiothoracic Surgery 2011, 6:3

- Conclusion:
- The results from this study suggest that there may be some benefit to tight glycaemic control during and after cardiac surgery. However, due to the limited number of studies available and the significant variability in glucose levels; period of control; and the reporting of outcome measures, further research needs to be done to provide a definitive answer on the benefits of tight glycaemic control for cardiac surgery patients.

http://aidenslegacy.org/about.html

CLINICAL CONCEPTS AND COMMENTARY

Jerrold H. Levy, M.D., F.A.H.A., F.C.C.M., Editor

Perioperative Hyperglycemia Management

An Update

Elizabeth W. Duggan, M.D., Karen Carlson, M.D., M.B.A., Guillermo E. Umpierrez, M.D., C.D.E.

CME

This article has been selected for the ANESTHESIOLOGY CME Program. Learning objectives and disclosure and ordering information can be found in the CME section at the front of this issue.

Elizabeth W. Duggan, MD, et al. Perioperative Hyperglycemia Management An Update. Anesthesiology 2017; 126:547–60

http://aidenslegacy.org/about.html

Table 1. Society Guideline Recommendations for Treatment of Perioperative Hyperglycemia and Diabetes

	Ambulatory Surgery	ICU	Non-ICU
SAMBA[50]	SC rapid-acting insulin analogs are preferred over IV or SC regular insulin		
	Treatment goal: intraoperative blood glucose levels < 180 mg/dl (10 mM)		
ADA/AACE[51]		Initiate insulin therapy for glucose > 180 mg/dl (10 mM)	Treatment goal: If treated with insulin, premeal glucose targets should generally be < 140 mg/dl (< 7.7 mM), with random glucose levels < 180 mg/dl (10 mM)
		Treatment goal: For most patients, target a glucose level between 140 and 180 mg/dl (7.7–10 mM).	
		Glucose target between 110 and 140 mg/dl (6.1–7.7 mM) may be appropriate for select patients if achievable without significant risk for hypoglycemia	
ACP[54]		Recommends against intensive insulin therapy in patients with or without diabetes in surgical/medical ICUs	
		Treatment goal: Target glucose is between 140 and 200 mg/dl (7.7–11.1 mM) in patients with or without diabetes	
Critical Care Society[52]		BG > 150 mg/dl (8.3 mM) should trigger insulin therapy	
		Treatment goal: Maintain glucose < 150 mg/dl (8.3 mM) for most patients in ICU	

Elizabeth W. Duggan, MD, et al. Perioperative Hyperglycemia Management An Update. Anesthesiology 2017; 126:547–60

	patients in ICU	
Endocrine Society[30]		Treatment goal: Target premeal blood glucose < 140 mg/dl (7.7 mM) and random glucose < 180 mg/dl (10 mM) Higher target glucose < 200 mg/dl (11.1 mM) is acceptable in patients with terminal illness and/or with limited life expectancy or at high risk for hypoglycemia
Society of Thoracic Surgeons[53]	Continuous insulin infusion preferred over SC or intermittent IV boluses Treatment goal: Recommend glucose < 180 mg/dl (10 mM) during surgery, ≤ 110 mg/dl (6.1 mM) in fasting and premeal states	
Joint British Diabetes Societies[55]		Initiate insulin therapy for glucose > 10 mM (180 mg/dl) Target blood glucose levels in most patients are between 6 and 10 mM (108–180 mg/dl) with an acceptable range of between 4 and 12 mM (72–216 mg/dl)

ACP = American College of Physicians; ADA/AACE = American Diabetes Association/American Association of Endocrinologists; ICU = intensive care unit; IV = intravenous; SAMBA = Society for Ambulatory Anesthesia; SC = subcutaneous.

Elizabeth W. Duggan, MD, et al. Perioperative Hyperglycemia Management An Update. Anesthesiology 2017; 126:547–60

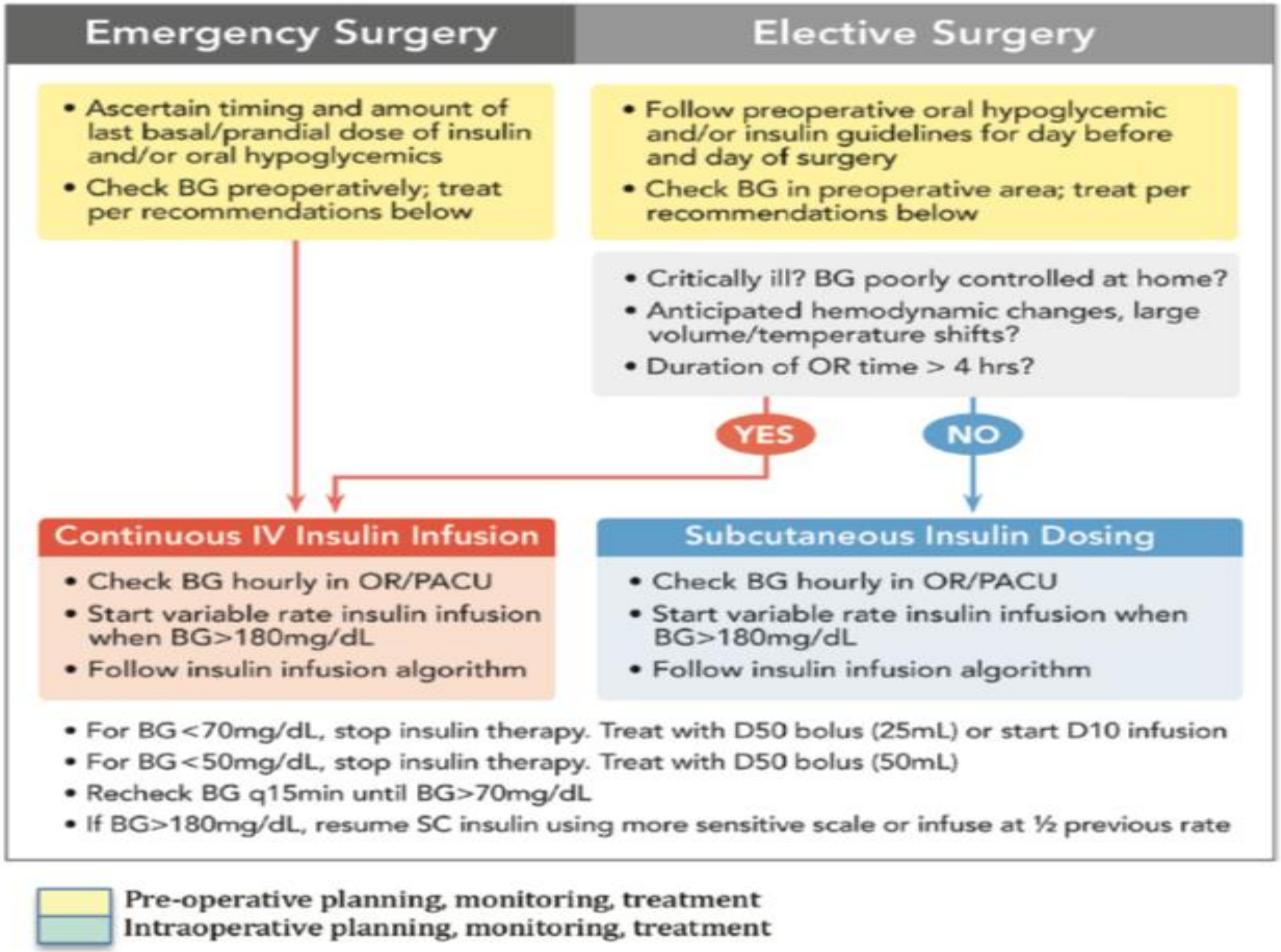


Fig. 2. Pre- and intraoperative testing and treatment algorithm (intravenous or subcutaneous insulin). BG = blood glucose; D10 = dextrose 10% solution; D50 = dextrose 50% solution; IV = intravenous; OR = operating room; PACU = postanesthesia care unit; q15min = every 15 min; SC = subcutaneous. BG 180 mg/dl = 10 mM; BG 70 mg/dl = 3.9 mM, BG 50 mg/dl = 2.8 mM.

Elizabeth W. Duggan, MD, et al. Perioperative Hyperglycemia Management An Update. Anesthesiology 2017; 126:547–60

Table 9 Recommended glucose target ranges for intensive care patients and related subgroups

Society, guideline	Patient group	Trigger BG value to start insulin infusion, mM (mg dl^{-1})	Target range, mM (mg dl^{-1})	Rationale
Society of Critical Care Medicine's clinical practice guideline[105]	General recommendation	8.3 (150)	5.6–8.3 (100–150)	
	Cardiac surgery		<8.3 (150)	Decreased risk for deep sternal wound infection and death[70 127–130]
	Critically ill trauma patients	8.3 (150)	<10 (180)	
	Traumatic brain injury[131 132]	8.3 (150)	<10 (180)	
	Neurological ICU patients - Ischaemic stroke[133–135] - Intraparenchymal haemorrhage[136] - Aneurysmal subarachnoid haemorrhage[137–139]	8.3 (150)	<10 (180)	
American Diabetes Association guidelines[29]	General recommendation	10 (180)	7.8–10 (140–180)	
	Adaptation		6.1–7.8 (110–140)	Adjust to lower target range in documented low rate of severe hypoglycaemia
American Association of Clinical Endocrinologists[111]	General recommendation		7.8–10 (140–180)	
	Surgical patients		Lower range	Only in units showing low rates of hypoglycaemia
Surviving Sepsis Campaign[103]	General recommendation	10 (180)	<10 (180)	Based on NICE-SUGAR study
Clinical Practical Guideline from the American College of Physicians[80]	General recommendation		7.8–11.1 (140–200)	If insulin infusion is applied. But guideline does not recommend intensive insulin therapy
Spanish Society of Intensive Care Medicine and Coronary Units[140]	General recommendation		<8.3 (150)	
French Society of Anaesthesia and Intensive Care[106]	General recommendation		10 (180)	
	Surgical patients		<6.1 (110)	
	Cardiac patients		<6.1 (110)	
Society of Thoracic Surgeons[20]	Cardiac surgery patients		<10 (180) except <8.3 (150) for those with devices in place	

Elizabeth W. Duggan, MD, et al. Perioperative Hyperglycemia Management An Update. Anesthesiology 2017; 126:547–60

Delex PHARMA INTERNATIONAL INC.
meeting the gaps in critical care

Diabetes and the Association of Postoperative Hyperglycemia With Clinical and Economic Outcomes in Cardiac Surgery

DOI: 10.2337/dc15-1817

Giampaolo Greco,[1] Bart S. Ferket,[1] David A. D'Alessandro,[2] Wei Shi,[1] Keith A. Horvath,[3] Alexander Rosen,[4] Stacey Welsh,[5] Emilia Bagiella,[1] Alexis E. Neill,[6] Deborah L. Williams,[1] Ann Greenberg,[3] Jeffrey N. Browndyke,[7] A. Marc Gillinov,[8] Mary Lou Mayer,[9] Jessica Keim-Malpass,[10] Lopa S. Gupta,[1] Samuel F. Hohmann,[11] Annetine C. Gelijns,[1] Patrick T. O'Gara,[12] and Alan J. Moskowitz[1]

Giampaolo Greco, et al. Diabetes and the Association of Postoperative Hyperglycemia With Clinical and Economic Outcomes in Car
DOI: 10.2337/dc15-1817

http://aidenslegacy.org/about.html

ICU FORUM
DPI CME TRAINING PROGRAM TRADEMARK

meeting the gaps in critical care

Table 2—Clinical and economic outcomes associated with postoperative hyperglycemia

Outcome	No DM: No hyperglycemia	No DM: Hyperglycemia	NITDM: No hyperglycemia	NITDM: Hyperglycemia	ITDM: No hyperglycemia	ITDM: Hyperglycemia
Hospital costs (U.S. $)						
Unadjusted mean (95% CI)	28,987 (27,850–30,246)	38,664 (36,537–40,856)	31,264 (28,134–34,744)	34,835 (31,845–38,730)	55,004 (45,104–67,403)	39,599 (35,072–44,371)
Adjusted Incremental (95% CI)*	Reference	3,192 (1,972 to 4,456)	Reference	2,151 (−572 to 5,034)	Reference	−6,225 (−12,886 to −222)
Hospital LOS (days)						
Unadjusted mean (95% CI)	8.7 (8.4–9.1)	11.3 (10.7–11.9)	9.7 (8.9–10.5)	10.7 (9.9–11.7)	16.6 (14.0–19.9)	12.4 (11.2–13.7)
Adjusted incremental (95% CI)*	Reference	0.8 (0.4–1.3)	Reference	0.6 (−0.2 to 1.5)	Reference	−1.6 (−3.7 to 0.4)
Composite clinical end point						
Unadjusted mean (95% CI)	0.262 (0.243–0.280)	0.310 (0.284–0.338)	0.310 (0.241–0.378)	0.406 (0.358–0.456)	0.430 (0.342–0.519)	0.305 (0.254–0.365)
Adjusted incremental (95% CI)*	Reference	0.038 (0.010–0.067)	Reference	0.126 (0.050–0.204)	Reference	−0.052 (−0.140 to 0.039)
Major infections						
Unadjusted mean (95% CI)	0.019 (0.013–0.025)	0.040 (0.030–0.051)	0.023 (0.005–0.048)	0.037 (0.019–0.057)	0.061 (0.019–0.112)	0.020 (0.006–0.036)
Adjusted incremental (95% CI)**	Reference	0.016 (0.005–0.028)	Reference	0.012 (−0.021 to 0.040)	Reference	−0.041 (−0.091 to 0.000)
Cardiac complications						
Unadjusted mean (95% CI)	0.150 (0.136–0.165)	0.178 (0.157–0.199)	0.161 (0.110–0.217)	0.222 (0.181–0.260)	0.193 (0.124–0.270)	0.164 (0.125–0.211)
Adjusted incremental (95% CI)**	Reference	0.016 (−0.010 to 0.042)	Reference	0.049 (−0.018 to 0.118)	Reference	−0.037 (−0.123 to 0.042)
Respiratory complications						
Unadjusted mean (95% CI)	0.133 (0.086–0.111)	0.166 (0.107–0.144)	0.190 (0.133–0.250)	0.232 (0.193–0.276)	0.307 (0.222–0.395)	0.180 (0.138–0.227)
Adjusted incremental (95% CI)**	Reference	0.026 (0.000–0.053)	Reference	0.042 (−0.034 to 0.114)	Reference	−0.125 (−0.224 to −0.030)

DM, diabetes mellitus. *Adjusted for age, gender, race, BMI, white blood cell count, GFR, hemoglobin, history of heart failure, renal insufficiency, ejection fraction, prior cardiac surgery, history of lung disease, corticosteroids, surgery time, sternotomy performed yes/no, surgery type, procedure, and study site. **Adjusted for age, gender, and procedure.

Gianpaolo Greco, et al. Diabetes and the Association of Postoperative Hyperglycemia With Clinical and Economic Outcomes in Car
10.2337/dc15-1817

http://aidenslegacy.org/about.html

DPI CME TRAINING PROGRAM TRADEMARK

Table 2—Clinical and economic outcomes associated with postoperative hyperglycemia

	No DM		
Outcome	No hyperglycemia	Hyperglycemia	No hyperglycemia
Hospital costs (U.S. $)			
Unadjusted mean (95% CI)	28,987 (27,850–30,246)	38,664 (36,537–40,856)	31,264 (28,134–34,744
Adjusted Incremental (95% CI)*	Reference	3,192 (1,972 to 4,456)	Reference
Hospital LOS (days)			
Unadjusted mean (95% CI)	8.7 (8.4–9.1)	11.3 (10.7–11.9)	9.7 (8.9–10.5)
Adjusted incremental (95% CI)*	Reference	0.8 (0.4–1.3)	Reference
Composite clinical end point			
Unadjusted mean (95% CI)	0.262 (0.243–0.280)	0.310 (0.284–0.338)	0.310 (0.241–0.378)
Adjusted incremental (95% CI)*	Reference	0.038 (0.010–0.067)	Reference
Major infections			
Unadjusted mean (95% CI)	0.019 (0.013–0.025)	0.040 (0.030–0.051)	0.023 (0.005–0.048)
Adjusted incremental (95% CI)**	Reference	0.016 (0.005–0.028)	Reference
Cardiac complications			
Unadjusted mean (95% CI)	0.150 (0.136–0.165)	0.178 (0.157–0.199)	0.161 (0.110–0.217)
Adjusted incremental (95% CI)**	Reference	0.016 (−0.010 to 0.042)	Reference
Respiratory complications			
Unadjusted mean (95% CI)	0.133 (0.086–0.111)	0.166 (0.107–0.144)	0.190 (0.133–0.250)
Adjusted incremental (95% CI)**	Reference	0.026 (0.000–0.053)	Reference

DM, diabetes mellitus. *Adjusted for age, gender, race, BMI, white blood cell count, GFR, hemoglobin, history of heart
corticosteroids, surgery time, sternotomy performed yes/no, surgery type, procedure, and study site. **Adjusted fo

Giampaolo Greco, et al. Diabetes and the Association of Postoperative Hyperglycemia With Clinical and Economic Outcomes in Car
DOI: 10.2337/dc15-1817

perglycemia

	NITDM		ITDM	
	No hyperglycemia	Hyperglycemia	No hyperglycemia	Hyperglycemia
	31,264 (28,134–34,744) Reference	34,835 (31,845–38,730) 2,151 (−572 to 5,034)	55,004 (45,104–67,403) Reference	39,599 (35,072–44,371) −6,225 (−12,886 to −222)
	9.7 (8.9–10.5) Reference	10.7 (9.9–11.7) 0.6 (−0.2 to 1.5)	16.6 (14.0–19.9) Reference	12.4 (11.2–13.7) −1.6 (−3.7 to 0.4)
	0.310 (0.241–0.378) Reference	0.406 (0.358–0.456) 0.126 (0.050–0.204)	0.430 (0.342–0.519) Reference	0.305 (0.254–0.365) −0.052 (−0.140 to 0.039)
	0.023 (0.005–0.048) Reference	0.037 (0.019–0.057) 0.012 (−0.021 to 0.040)	0.061 (0.019–0.112) Reference	0.020 (0.006–0.036) −0.041 (−0.091 to 0.000)
	0.161 (0.110–0.217) Reference	0.222 (0.181–0.260) 0.049 (−0.018 to 0.118)	0.193 (0.124–0.270) Reference	0.164 (0.125–0.211) −0.037 (−0.123 to 0.042)
	0.190 (0.133–0.250) Reference	0.232 (0.193–0.276) 0.042 (−0.034 to 0.114)	0.307 (0.222–0.395) Reference	0.180 (0.138–0.227) −0.125 (−0.224 to −0.030)

moglobin, history of heart failure, renal insufficiency, ejection fraction, prior cardiac surgery, history of lung disease, d study site. **Adjusted for age, gender, and procedure.

Gianpaolo Greco, et al. Diabetes and the Association of Postoperative Hyperglycemia With Clinical and Economic Outcomes in Car
10.2337/dc15-1817

- Findings suggest that current recommendations, which use a single maximum glucose threshold for the control of stress hyperglycemia after cardiac surgery, may not achieve the intended benefits in all patient subgroups.
- Such a blanket approach could instead be harmful to patients with more advanced diabetes.
- Given the substantial clinical and economic benefits that may be attained, patient stratification with indicators of chronic glucose dysregulation should be investigated.

Gianpaolo Greco, et al. Diabetes and the Association of Postoperative Hyperglycemia With Clinical and Economic Outcomes in Car

DOI: 10.2337/dc15-1817

http://aidenslegacy.org/about.html

Summary

http://aidenslegacy.org/about.html