Clinical Professor of Medicine
Director, Metabolic Support
Division of Endocrinology, Diabetes, and Bone Disease
Mount Sinai School of Medicine

AACE Treasurer and Vice President
ACE Secretary/Treasurer

ENTERAL NUTRITION
FORMULATION AND DIABETES
Relevant Disclosures

- Abbott nutrition – program development and lecture honoraria
- Select Medical Corporation – research grant
Outline

- General nutritional strategies for prediabetes and diabetes (T1D and T2D)
- Indications for enteral nutrition (EN)
- Synchronizing insulin with EN protocols
- Clinical evidence
- Conclusions
Inpatient Hyperglycemia

- Nearly 100% of ICU patients will have hyperglycemia (defined > 110 mg/dl)
- 38% of non-ICU patients will have hyperglycemia (various definitions, generally > 140-180 mg/dl)
- Independent variables: mean BG, glycemic variability, severe hypoglycemia (< 40 mg/dl)
- Separate effects of
  - pre-existing diabetes on organ function
  - Hyperglycemia/insulinization on inflammatory markers
Nutritional Strategies

- All – conform with principles of healthy eating patterns in format of tube feeds; achieve target BG, reduce glycemic variability, and avoid hypoglycemia
- T1D – synchronizing carbohydrate with insulin; insulin on-board at all times
- T2D – above + reducing cardiometabolic risk factors
- Stress hyperglycemia (SH) – achieving target glycemic control
- Prediabetes – avoiding hyperglycemia, reducing cardiometabolic risk markers
Indications for EN

1. Screening all patients for nutritional risk within 24 hrs of admission; increased risk in 12-55% (The Joint Commission)
2. Formal nutritional assessment of patients at increased risk (NRS 2002; NRI)
3. Uncertain, nonfunctional, and/or inaccessible GI tract
4. Expectation of duration of at-risk state > 5-7 days
5. Organ function and glycemic status
6. Formulation of EN
EN Formulation

- Nutritional diagnosis
  - Simple malnutrition (undernutrition)
    - marasmus
  - Complicated malnutrition (dysmetabolism)
    - Adult kwashiokor-like
    - Cytokine mediated, hypoalbuminemic
  - Cachexia/wasting/sarcopenia
  - Mild/moderate/severe
  - Coding: 260, 261, 262, 263, 263.1, 273, 579.3, 579.9, 799.4
Special considerations

- Volume status
- Risk for refeeding syndrome
- Micronutrient deficiencies
- Gastroparesis/diarrhea/short bowel
- Renal/hepatic status
- Polypharmacy
- Time schedule (e.g., physical therapy; social)
Select Route

- Nasogastric tube (NGT)
  - Endoscopic placement
  - Advanced to postpyloric placement
- Gastrostomy tube (GT)
  - Percutaneous endoscopically placed (PEG)
  - Fluoroscopic guidance
  - Surgical placement
- Postpyloric feeding tube (duodenal)
- Jejunostomy tube (JT; PEJ; surgical)
Selection of EN product

- Polymeric (whole protein) – less expensive
  - with/without fiber
  - Renal/hepatic formulas

- Semi-elemental
  - Protein hydrolysates
  - Medium-chain triglycerides (MCT)
  - Micronutrient content
  - Nutritional pharmacology

- Elemental
  - Free amino acids
  - 1, 1.2, 1.5, 1.8 kcal/cc
Diabetes-specific formulas

- Low carbohydrate (35-40%)
- Modified maltodextrin – slower digestion and absorption (α 1-4 linkage)
- May have fructose
- Modified fat source to contain mono-unsaturated fatty acid (MUFA)
- Whole protein source
- Fiber
- Chromium, carnitine, B-complex
Synchronization: insulin & feeds

- **24 h continuous feeds**
  - NPH q 6; detemir q 8; glargine q 12
  - T2D: 0.2 – 0.4 to 0.6 – 0.9 unit/kg/d (less with SH)
  - T1D: 0.25 unit/kg/d + 1 unit per 10-15 g carbohydrate
  - Uptitrate as feeds advanced before hyperglycemia
  - Correction with rapid-acting insulin

- **10-18 h cycled feeds**
  - Start: 55% TDD NPH or detemir
  - Start: 15% TDD rapid-acting insulin to simulate incretin response
  - 8-12 h later (if 18 h cycle): 30% TDD with NPH or detemir
  - Correction; basal insulin off feeds as needed
Synchronization (continued)

- **Bolus feeds**
  - Rapid-acting insulin at start of bolus (can start at 0.1 unit per g carbohydrate)
  - Titrate to post-bolus or next pre-bolus BG target
  - Add basal insulin if post-bolus at goal but fasting BG is elevation
  - Add correction rapid-acting insulin
  - Remember T1D always needs basal insulin on-board

- **Hybridized nutrition**
  - Can layer strategies for po, bolus, cycled feeds as patients are transitioned
VOLUME-BASED FEED PROTOCOLS (BLUE) PROVIDE MORE CALORIES (LEFT) AND PROTEIN (RIGHT) THAN STANDARD RATE-BASED FEED PROTOCOLS (RED)
Safer glycemic control using isomaltulose-based enteral formula: A pilot randomized crossover trial

Moritoki Egi MD,*, Yuichiro Toda MD, PhD, Hiroshi Katayama MD, PhD, Masataka Yokoyama MD, PhD, Kiyoshi Morita MD, PhD, Hidekazu Arai PhD, Tomoki Yamatsuji MD, PhD, Michael Bailey PhD, MSc, BSc(hons), Yoshio Naomoto MD, PhD

<table>
<thead>
<tr>
<th></th>
<th>IF</th>
<th>SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kcal/mL)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Protein (energy %)</td>
<td>20</td>
<td>16%</td>
</tr>
<tr>
<td>Fat (energy %)</td>
<td>29.7</td>
<td>25.2</td>
</tr>
<tr>
<td>Carbohydrate (energy %)</td>
<td>50.3</td>
<td>58.8</td>
</tr>
<tr>
<td>Composition of carbohydrate</td>
<td>Dextrin, 22.8%</td>
<td>Dextrin, 40%</td>
</tr>
<tr>
<td></td>
<td>Isomaltulose, 68.3%</td>
<td>Glucose, 20%</td>
</tr>
<tr>
<td></td>
<td>Other, 8.9%</td>
<td>Fructose, 21%</td>
</tr>
<tr>
<td></td>
<td>Other, 19%</td>
<td></td>
</tr>
</tbody>
</table>

Mean blood glucose concentrations (mg/dL)

- **Standard balanced formula**
- **Isomaltulose-based formula**

Significant difference (11 a.m. – 12 p.m.)

Mean blood glucose concentrations (mg/dL)

- Administration of enteral nutrition
- Stop feeding
Glycemic variability is an independent marker for ICU outcome.

A Diabetes-Specific Enteral Formula Improves Glycemic Variability in Patients with Type 2 Diabetes

Carolyn J. Alish, Ph.D., R.D.,¹ W. Timothy Garvey, M.D.,²,³ Kevin C. Maki, Ph.D.,⁴ Gordon S. Sacks, Pharm.D., R.Ph., B.C.N.S.P.,⁵ Deborah S. Hustead, Ph.D.,¹ Refaat A. Hegazi, M.D., Ph.D.,¹ and Vikkie A. Mustad, Ph.D.¹

[Graphs and figures showing changes in adjusted plasma glucose and adjusted serum insulin levels over time for DSF and STF, and a bar graph comparing MAGE levels for STF and DSF.]
Clinical Observation

Comparison of 70/30 Biphasic Insulin With Glargine/Lispro Regimen in Non–Critically Ill Diabetic Patients on Continuous Enteral Nutrition Therapy

Elisa Hsia, MD; Stacey A. Seggelke, RN, MS, CDE; Joanna Gibbs, PA-C; Neda Rasouli, MD; and Boris Draznin, MD, PhD
Exogenous glucagon-like peptide-1 attenuates the glycaemic response to postpyloric nutrient infusion in critically ill patients with type-2 diabetes.

Ensuring 1 CC/Min X 4H: Decr BG, INCR INS, and Decr GLUCAGON with GLP-1
Clinical Observations

Chromium Infusion Reverses Extreme Insulin Resistance in a Cardiothoracic ICU Patient

Michael Via, MD; Corey Scurlock, MD; Jayashree Raikhelkar, MD; Gabriele Di Luozzo, MD; and Jeffrey I. Mechanick, MD

[Graph showing glucose levels with a highlighted period for chromium infusion]
Improved glucose control associated with i.v. chromium administration in two patients receiving enteral nutrition

OLIVIA J. PHUNG, ROBERT A. QUERCIA, KEVIN KEATING, WILLIAM L. BAKER, JENNIFER L. BELL, C. MICHAEL WHITE, AND CRAIG I. COLEMAN

Am J Health-Syst Pharm. 2010; 67:535-41

CHROMIUM 150 MCG/DAY X 4 DAYS
Conclusions

- Routine nutrition risk stratification of all patients (inpatient and outpatient)
- Routine glycemic control in all patients receiving EN (with or without diabetes)
- Preferential use of insulin to achieve glycemic control in patients receiving EN
- Preferential use of diabetes specific formulas
- Addressing glycemic variability and hypoglycemia as important as hyperglycemia and average BG