Goals and Objectives

- Describe at least two strategies for managing the impact of ICU insulin protocols on new admissions to secondary care facilities.
- List at least 3 risk factors for skin breakdown and poor wound healing associated with diabetes.
- Explain at least 2-3 considerations in selecting nutritional formulas/supplements for individuals with diabetes.

Who Are Our Patients

Acute Illness → Acute Inflammatory Response (2-25 days post injury)

- Obesity, Diabetes, Organ compromise, Multiple co-morbidities, Aging population
- PrU development, delayed wound healing, poor response to standard interventions, need for BG & GI monitoring

Consequences of Inflammatory Response Cycle

- Arginine and glutamine deficiency within 24 hrs of acute illness, trauma and/or surgery
- Micronutrient deficiencies
- Hyperglycemia even in non-diabetics.
- Anorexia and Involuntary weight loss
- Low albumen causes edema which masks weight loss and can impair nutrient adsorption
Add to this the Prevalence of Diabetes Stress + Pre-existing DM/Pre-DM

- In 2010 among U.S. residents
  - Age 65 y & older, 10.9 million, or 26.9 %, had diabetes.
  - Age < 20 y, about 215,000 had Type 1 or Type 2 DM.
  - Age 20 y & older, about 1.9 million were newly diagnosed with DM.
  - Age 20 y & older, an estimated 79 million American adults had pre-diabetes.


Drug & Stressed Induced Hyperglycemia

- Patients without diabetes who experience pronounced hyperglycemia (BG > 110 mg/dl) and prolonged ICU LOS are at risk for the same complications experienced by patients with diabetes, including DKA.
- Glycemic control in ICU patients has been shown to reduce mortality & improve outcomes. Subsequently all most all ICU patients are started on insulin.


Impact for Hospitalized Patients

- Significant increase in insulin management, protocol development with staff training and greater risk for hypoglycemia.
- Unclear if non-diabetic patients with hyperglycemia in the hospital had only stress hyperglycemia or were actually unrecognized diabetics – compromises safety of discharge:
  - Patients with hyperglycemia or newly Dx diabetes, should receive counseling and, if BGs are significantly high, pharmacotherapy upon discharge
  - Who has the staffing for this level of discharge needs?


Impact of ICU Insulin Protocols on Secondary Care Facilities

- Increase in patients on insulin without warning.
  - Confused patients as to why they are on insulin.
  - Clinical Staff unfamiliar with new ICU protocols, new BG targets, new DM medications, safety risks...
  - Increased medication administration, accu checks/BG monitoring, more A1Cs to clarify unclear dx of DM
  - Increased DM supplements/diets and diabetic teaching including BG testing & insulin administration
  - Increased risk for hypoglycemia, especially for tube fed/NPO patients on day of transfer.
Consequences of Hyperglycemia

- Dehydration
- Continued loss of LBM
- Impaired immune function
  - Macrophages stop functioning if BG > 140 mg/dl
- Infectious complications
- Poor wound healing
  - Increased oxidative stress, decreased profusion, increased neuropathy
- Altered GI function
  — Gastroparesis, Constipation, Diarrhea


American Diabetes Association
Criteria for the Diagnosis of Diabetes

1. **A1C >6.5%** — Measurement misleading in certain anemias, ESRD, Hemoglobinopathies. Differs between patients based on age, ethnicity, ? other factors (“glycation gap”). (see www.NGSP.org)

2. **FPG >126 mg/dL** — fasting is defined as no caloric intake for at least 8 h

3. **2-h plasma glucose >200 mg/dL** during a 75 gram OGTT

In the absence of unequivocal hyperglycemia (classic symptoms of hyperglycemia and a random PG >200 mg/dl), these criteria should be confirmed by repeat testing on a different day.


New ADA Categories of Increased Risk for Diabetes*

1. **FPG 100-125 mg/dL** (5.6-7.0 mmol/L) [IFG]
   
2. **2-h PG 75-g OGTT 140-199 mg/dL** (7.8-11.1 mmol/L) [IGT]
   
3. **A1C 5.7% to < 6.5%**

*For all 3 tests, risk is continuous, extending below the lower limit of the range and becoming increasingly great at higher ends of the range.


Blood Glucose Targets in the Hospital

- **Most ICU patients**
  - BG: 110 to 180 mg/dl.
- **Outside the ICU**
  - BG: 100 to 140 before meals
  - BG: below 180 at other times
- **Avoid BG <70, bring high BG down slowly**
  - Hypoglycemia patient handout
Cluster of biomarkers which correlate with vascular complications and poor wound healing

• **HbA1c**
  - Can show long-term hyperglycemia or early diagnosis for early intervention
• **Nitric Oxide**
  - Responsible for vasodilation and macrophage function
  - Low levels in DM can be corrected with supplemental Arginine
• **Serum Glucose**
  - Hyperglycemia is pro-inflammatory state, associated with increased IL-8 cytokines and delayed wound healing,
  - BG > 140, macrophages stop working
• **Lipid Profile**
  - Hyperlipidemia-induced oxidative stress - goes hand-in-hand with insulin resistance and obesity

Review: DM Type 1
β-cell destruction usually leading to absolute insulin deficiency, risk for ketoacidosis

• Can develop at any age, but it typically appears during childhood or adolescence.
• Requires both bolus and basal insulin
  - mealtime & snack insulin (bolus)
  - 24 hour steady low dose of insulin (basal)
• No insulin for 4 or more hours = risk for DKA
  - BG usually > 240 + urinary ketones
  - Can have hyperglycemia w/o DKA
• **NEVER hold basal insulin**

DM Type 2
A progressive condition with increasing insulin resistance and/or decreasing insulin secretion.

• Can occur at any age & weight, more common in overweight adults.
• Oral medications given to reduce insulin resistance and/or stimulate insulin secretion, many op for insulin to reduce cost.
• Over time, the ability to secrete insulin is lost and oral medications become ineffective – **insulin is eventually required to prevent DKA.**

Exogenous Human Insulin Used to Mimic Normal Insulin Action

**Bolus Insulins**
- **Rapid Acting**
  - Humalog (Lispro)
  - Novalog (Aspart)
  - Apidra (Glulisine)
- **Short Acting**
  - Regular (Novolin R, Humulin R)

**Basal Insulins**
- **Intermediate**
  - NPH (Novolin N, Humulin N)
- **Long-Acting**
  - Lantus (glargine)
  - Levemir (detemir)

**Fixed Combinations**
- **NPH/Reg**
  - Humalin 70/30
  - Novolin 70/30
  - Humulin 50/50
  - Novalin 50/50
- **Protamine/Rapid**
  - Humalog 75/25
  - Humalog 50/50
  - Novalog 70/30
### Bolus Insulins – Meals, Snacks & Coverage

- **Rapid Acting**
  - Lispro & Aspart
- **Short Acting**
  - Regular

<table>
<thead>
<tr>
<th>Onset</th>
<th>Peak</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-15 min</td>
<td>30-90 min</td>
<td>&lt;5 hrs</td>
</tr>
<tr>
<td>30-60 min</td>
<td>2-3 hrs</td>
<td>5-8 hrs</td>
</tr>
</tbody>
</table>

**Risk for Stacking**

Boluses given too close together overlap & yield a higher dose. After injection, 20-25% of the bolus is used up each hour.

Safety Tip: Separate bolus insulin injections by 4 hours to avoid stacking

### Basal “Steady”

- **Intermediate**
  - NPH

<table>
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<tr>
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<th>Peak</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-4 hrs</td>
<td>4-10 hrs</td>
<td>10-16 hrs</td>
</tr>
</tbody>
</table>

- **Long-Acting**
  - (Can not be mixed with other insulins)
  - Lantus
  - Levemir

### Fixed Combinations = Bolus + Basal

#### Novalin 70/30 (NPH/Reg)

- Can only be mixed with regular insulin given for coverage
- Dosed: BID ac B&D

<table>
<thead>
<tr>
<th>Onset</th>
<th>Peak</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-60 min</td>
<td>Dual 2-3 hrs &amp; 4-10 hrs</td>
<td>10-16 hrs</td>
</tr>
</tbody>
</table>

#### Novalog 70/30 (Protamine/Aspart)

- Can only be mixed with Aspart insulin given for coverage
- Dosed: BID ac B&D

<table>
<thead>
<tr>
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<th>Peak</th>
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<tbody>
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<td>5-15 min</td>
<td>Dual 30-90 min &amp; 4-10 hrs</td>
<td>10-16 hrs</td>
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</table>

### Secondary Care Facilities

**Who Are Our Patients?**

- **Malnutrition & Pressure:**
  - Admission to ICU and advanced age high risks for both
  - PrUs: ICU=28.7% & Acute Care=21.6%¹
  - Malnutrition = 200%-500% higher risk for PrUs²
  - Transfers from acute care to sub-acute: “>91% of subjects were either malnourished or at risk of malnutrition”³

- **Magee Admission Data 2013:**
  - 33% w/PrUs, 35% also w/surgical wounds,
  - 50% on insulin w/unclear dx of DM, all w/malnutrition.

---

“Insulin Task Force”

- Assess risks associated with & areas for improvement related to diabetes management
- Determine which patients are at greatest risks for transfers out, poor glycemic control
- Assess staff’s (MDs, RNs, RDs, CNAs, Pharmacists, Therapists and Administrators) current understanding of insulin management.
- Develop guidelines and implement changes to current practices to improve patient safety.

Safety Strategies to Consider

- Reduce the number of insulins on formulary
  — Regular insulin removed from formulary
  — Only one rapid acting insulin (lispro) used for mealtime and correctional insulin doses.
  — Pre-mixed insulin- limited use, patient specific
  — Use same manufacturer for all insulin as able
  — Only one long-acting insulin (glargine)
    • Ordered at “q 9pm”, discourage > 1 injection / day

Magee’s Correctional Dosing Scales, More than one option

<table>
<thead>
<tr>
<th>Glucose Level</th>
<th>Insulin Sensitive Coverage Dose Regimen</th>
<th>Insulin Standard Coverage Dose Regimen</th>
<th>Insulin Resistant Coverage Dose Regimen</th>
<th>Use Insulin Pump Bolus Calculator</th>
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<tr>
<td></td>
<td>0700 to 1900, no coverage 1901 to 0659</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 60</td>
<td>Treat &amp; Call MD 0</td>
<td>Treat &amp; Call MD 0</td>
<td>Treat &amp; Call MD 0</td>
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<td>60-150</td>
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<td>151-200</td>
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<td>3</td>
<td></td>
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<tr>
<td>201-250</td>
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<td>4</td>
<td>6</td>
<td></td>
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<tr>
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<td></td>
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<tr>
<td>301-350</td>
<td>4</td>
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<td>Call MD 15 Call MD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;400</td>
<td>Call MD Call MD Call MD</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Our Experience

Safety Strategies to Consider

- Sliding scale only in effect 7AM – 7PM*
  — Accu check order options & visible on the MedAct
    • Accucheck AC & HS w SS coverage AC only
    • Accucheck 3 AM, no insulin
    • Accucheck AC & HS, no insulin
    • Accucheck q 6 hrs, no insulin at midnight
  — *Coverage 7:01pm to 6:59am given only after speaking with MD with review of BG trends.
Our Experience
Safety Strategies to Consider

If NPO on tube feedings (Highest Risk):

- Accuchecks q 6 hours, not AC and HS
- Insulin orders reduced by @ least 50%
  - 24 hour feeding → 14 hour feeding for rehab schedule
  - Rate of TF → decreased to 40mls/hr or hold if impaction likely
  - Change in TF formula likely – we selected a default formula to standardize transition to Rehab formulary

Rational for Default Formula

- Transfer TF formulas typically contain
  - 35 to 50% of calories from CHO with 24g of fiber/1500 kcals
  - 25 to 45% of kcals from omega 6 fat with little or no MCT oil.

- Criteria for default formula
  - Safe for any patient,
  - Fiber free given risk of bowel impaction (gastroparesis, opioids, Spinal Cord Injury),
  - Low CHO,
  - Low volume/ calorie dense, and
  - Good bowel tolerance

To achieve this, we looked for higher fat formulas with higher % of fat from MCT.

Patients with PrUs + Diarrhea + ALB < 3.0

- Check for impaction – stool pushing past block
- Facilitate Absorption & Reduce watery Stool
  - Peptide based formula¹ with higher % of fat from MCT
  - ALB < 2.5 associated with malabsorption
  - Insoluble fiber TF will not correct malabsorption and carries risk of impaction, especially w/gastroparesis
  - Consider prebiotics, soluble fiber², banana flakes
  - Hydrolyzed protein modular prn, closest to isotonic
  - Powdered not liquid vitamin/minerals prn
- Document anticipated wt loss with correction of edema

Medium Chain Triglycerides

- Absorbed from intestines directly into liver by portal vein - Used for malabsorption syndromes (better bowel tolerance than LCT)
- Reduces intracellular lipids in muscle tissue, reducing insulin resistance
- Rapidly oxidized by the liver for a quick fuel source
- Reduces production of LDL, but no effect on HDL
- Provides additional calories without contributing to glycemic load

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Medium Chain Triglyceride Oil Consumption as Part of a Weight-Loss Diet Does Not Lead to an Adverse Metabolic Profile When Compared to Olive Oil 

Medium-Chain Fatty Acids Improve Cognitive Function in Intensively Treated Type 1 Diabetic Patients and Support In Vitro Synaptic 
**Tube Feedings**  
Nursing Considerations

- Verify the type of tube feeding and pump settings with tube feeding order before EACH feed
- If NPH ordered “@6pm w/start of TF” – wait to give NPH until able to start TF (bath nights)
- May need to underfeed at first, adjust insulin, then increase calories as able / as appropriate
- Contact the Dietitian for TF related issues, i.e. N/V/D/C or uncontrolled blood sugars

**Bowel Impaction Risk Assessment**  
RD-RN-MD

- Date of last BM and Bristol Stool Type (consistency)
- Medication review: Bowel meds, pain meds - opioids
- Patient c/o N/V or been able to taste the TF
- H/O ileus, bowel impaction, constipation, aspiration pneumonia, C.diff, rectal tube
- Hard, distended abdomen,
- Previous TF = high fiber formula
- Signs of dehydration: urine, oral cavity, low TF flushes

**Nursing Orders**

- If patient assessed for possible impaction,
- Give enema on admit before start of TF
- Hold TF until “Good” results with bowel routine
- Keep HOB locked @ 30 degrees or keep patient upright in chair while TF is running.
- Hold TF for
  - N/V, increased coughing
  - Patient is able to taste TF when asked
  - TF tinted secretions
  - Residuals ≥ 250 - 500 mLs

**Case Report: Aspiration-Constipation**

- 84 y.o. F. C6 quadriplegia w/neurogenic B & B
- s/p anterior cervical decompression & fusion w/ PEG placement for post-op dysphagia.
- PMH: HTN, DM2 on insulin, high cholesterol.
- Transfer Report
  - Patient “coughed and used Yankaur all night.”
  - Date of last BM unknown, no bowel medications
  - AM glargine (24 units) given at 8am
  - High fiber TF @ 85mls/hr ATC stopped at 11am
  - “Skin intact”
RN-RDN Assessment Highlights

• Stage 3 sacral pressure ulcer
• Tea colored urine, dry oral cavity w/tongue sticking to palate and interfering with speech
• 22 lb wt loss, not including edema and stool wt
• Hard distended abdomen with bowel sounds present
• Per patient, “Yes, I could taste my TF, I just used the suction thing”

Case Report: Welcome to Rehab

• BG = 45, on admission at 3:30pm.
• 8 oz OJ via PEG. BG drop to 34.
• 120mls oral supplement via PEG. BG = 74.
• Insulin held. Accu checks q 4 hours.
• TF started @ low rate of 25 mls/hr, but stopped at 7pm for c/o tasting the TF
• IV D50 needed for BG of 50 at 12am

Case Report (cont)

• Bowel Program and abdominal x-ray ordered.
• IVF for first 3 days
• TF @ goal by 4th day with flushes 350 mLs TID; 40 mLs/hr w/TF
• Additional protein added including arginine & glutamine once dehydration corrected.
• Insulin: Glargine 8 units q 9 pm & NPH 5 units q 6 pm with start of tube feeding.
• Average BG = 125-165; Accu checks q 6 hours
• PrU resolved after 25 days
Diarrhea + ALB < 3 + Skin Breakdown

Patient with chronic diarrhea despite use of different TFs available to dietitian at transferring hospital.

Diarrhea resolved within 3 days of admission with small peptide/high MCT TF and 2 days of banana flakes.

Transition to Oral Intake

- Adjust time of TF to allow for meals, then decrease rate as oral intake increases.
- Adjust insulin, may be able to wean off insulin once off TF. Expect elevated BG during transition.
- Add oral supplement similar to default TF – low carb, good GI tolerance & safe for dysphagia.
- Consider at least 6g of arginine/day if diabetic wound present.
- Maintain tube for fluids or protein modular prn.

Questions?

CONTRIBUTING FACTORS TO ICU HYPERGLYCEMIA

- Calories / dextrose from parenteral & enteral nutrition.
- Corticosteroids, immunosuppressants and sympathomimetics.
- Steroids both increase glucose production & increase insulin resistance independent of food intake.
- Obesity epidemic / increased insulin resistance
- Tighter glucose control = improved outcomes
- Almost all ICU patients are started on insulin

Intermediate Insulin - NPH

<table>
<thead>
<tr>
<th>Time Given</th>
<th>NPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 am</td>
<td>10 am - noon</td>
</tr>
<tr>
<td>Noon</td>
<td>2 - 4 pm</td>
</tr>
<tr>
<td>5:00 pm</td>
<td>7 - 9 pm</td>
</tr>
<tr>
<td>8:00 pm</td>
<td>10 pm - 12 am</td>
</tr>
<tr>
<td>9:00 pm</td>
<td>11 pm - 1 am</td>
</tr>
</tbody>
</table>

- Onset: 2-4 h
- Peak: 4-10 h
- Done: 10-16 h

U-500 Regular Insulin
Not for Ordinary Use

- 5x more potent than standard U-100 insulin.
- Used when high doses of insulin (over 200 U/day or greater than 100 U per injection) are required.
- IV use is not recommended due to risk of overdose.
- Usage is on the rise due to:
  - obesity epidemic / increased insulin resistance
  - tighter glucose control protocols, and
  - utilization of insulin pumps.

U-500 Regular Insulin

- The high concentration of U-500 results in delayed absorption and it is dosed similar to NPH, with 2 to 3 injections per day using a TB syringe.
- Difficult to convert dose of U-500 R to any other insulin.
  - Use U-500 R only if patient was taking U-500 R at home
  - Keep drug in Pharmacy & have injections drawn up by Pharmacy

Review: Non-Diabetic Insulin Action

- Basal Insulin “24/7”
  - A steady supply of insulin into the blood
  - Controls blood glucose levels between meals and helps release energy throughout the day.
- Bolus Insulin “Prn”
  - A burst of insulin into the blood when a person eats a meal or snack.

**Long-Acting Basal Insulin**

<table>
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<th>Time Given</th>
<th>Lantus</th>
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<tbody>
<tr>
<td></td>
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<td>10 am - noon</td>
</tr>
<tr>
<td>9:00 pm</td>
<td>11 pm - 1 am</td>
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</table>

- No mixing with other insulins
- Same time every day
- Basal dose is adjusted based on BG trends, not held for one low BG. If you hold it, you affect the next 24 hours
- Typically need bolus or oral agent to cover meals & snacks

**Value of Medium Chain Triglycerides**

“A Neutral Saturated Fat”

- Dietary fats containing saturated fats primarily in sn–1 and -3 positions (e.g., cocoa butter, coconut oil, and palm oil)
- Has very different biological consequences than those fats in which the saturated fats are primarily in the sn–2 position (e.g., milk fat and animal fat/lard).