Diagnosis

- Fasting glucose ≥ 200 (more than 8 hours without calorie containing substances)
- 2 hr blood post glucose load of glucose ≥ 200
  - (1.75 grams/kg to a maximum of 75 grams)
- “Casual” or “random” glucose ≥ 200
- Hgb A1c ≥ 6.5%
- Confirmatory test (2nd test recommended)
  - Especially if asymptomatic

Etiology

- Impaired fasting glucose (IFG)
  - Fasting blood sugar ≥ 100 and <125
- Impaired glucose tolerance (IGT)
  - 2 hour postprandial ≥ 125 and <200
- Different standards
  - 1 hour peak >200 means......?
- Hgb A1c in special populations and conditions
  - E.g., increased RBC turnover results in falsely low results
- Children ....???

In-patient Management

- Standard Orders

The Team

- Meredith – diagnosed at age 3

Future Pediatric Endocrinologist

- Meredith – diagnosed at age 3

Diagnostic “Gray Zones”
Diagnostic Caveats

- Beware of small, sick, septic or “shocky”
  - High rates of glucose infusion coupled with poor perfusion and/or increased stress hormones
- Methods of measurement matter
  - Bedside testing using meters susceptible to technical errors
- False positives and negatives
  - Wrong dose of glucose used in children and youth
  - Some hemoglobin variants interfere with assay

Insulin Production vs Requirement

- The maintenance of normal blood glucose is a balance between insulin production and requirement.
- Insulin requirement is dependent on the sensitivity to insulin.
- Insulin sensitivity is affected by:
  - Genetics (non-Hispanic whites are more sensitive)
  - Inflammation
  - Hormones and medications (e.g., glucocorticoids)
  - Tissue type (muscle is more sensitive than adipose)

ADHD is contagious! Oh look there is a squirrel!

Diabetes Happens (and so do boo-boos)

- Loss of production capacity
  - Type 1 diabetes, pancreatitis
  - Decreased production capacity
  - Maturity onset of diabetes in youth
  - Increased requirement for insulin
  - Increased fat mass (Type 2 diabetes)
  - Medications (glucocorticoids)
- Combinations
  - Gradual decline in B-cell function and increased fat mass typically seen with aging
**Type 1 Etiology**

Destruction of B-cells by autoimmune processes

- Genetic factors
  - 6% risk if father with DM2, 3% risk if sibling or mother
  - 20% risk if fraternal twin, 30% if identical twin
  - 28 genetic variants associated with increase risk:
    - four on chromosome 12,
    - three on chromosome 16,
    - two on chromosomes: 1, 2, 16, 17, 20, 21 and 22

- Infectious agents
  - Coxackie, mumps, rubella

- Environmental exposures/toxin
  - Cows milk, early cessation of breast feeding

**Type 2 Etiology**

- Increased fat mass
- Decreased muscle mass
- Reduced B-cell function in due to persistently elevated glucose and free fatty acids
- Genetic susceptibility
  - Ethnicity
  - Family

**Maturity Onset Diabetes of Youth (MODY)**

- Single gene defects
- Inherited as autosomal dominant conditions
- Involve genes in critical pathways
  - Signaling pathways for insulin release in response to glucose
  - Insulin biosynthetic pathways
  - Islet cell development and aging
- New ones continue to be discovered

**Maturity Onset Diabetes of Youth (MODY)**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>GENE/PROTEIN</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODY 1</td>
<td>hepatocyte nuclear factor 4α</td>
<td>due to a loss of function mutation in the HNF4α gene</td>
</tr>
<tr>
<td>MODY 2</td>
<td>glucokinase</td>
<td>due to any of several mutations in the GCK gene</td>
</tr>
<tr>
<td>MODY 3</td>
<td>HNF-1α</td>
<td>mutations of the HNF-1α gene, a homeobox gene</td>
</tr>
<tr>
<td>MODY 4</td>
<td>insulin promoter factor-1</td>
<td>one of the less common forms of MODY, with some distinctive clinical features, including atrophy of the pancreas and several forms of renal disease.</td>
</tr>
<tr>
<td>MODY 5</td>
<td>HNF-β</td>
<td>Kruppel-like factor 11 has been associated with a form of diabetes that has been characterized as “MODY7”</td>
</tr>
<tr>
<td>MODY 6</td>
<td>meiogenic differentiation</td>
<td>Kruppel-like factor 11 has been associated with a form of diabetes that has been characterized as “MODY7”</td>
</tr>
<tr>
<td>MODY 7</td>
<td>bile salt dependent lipase</td>
<td>CEL has been associated with a form of diabetes that has been characterized as “MODY8”</td>
</tr>
<tr>
<td>MODY 8</td>
<td>PAX4</td>
<td>Spectrum from Insulin Deficiency to Insulin Resistance</td>
</tr>
</tbody>
</table>

**Diabetes "Types" and "Blends"**

Spectrum from Insulin Deficiency to Insulin Resistance

- Type 1
  - With increasing body fat and genetic risks can become very insulin resistant
- Type 2
  - With prolonged poor glycemic control and long-standing diabetes, B-cell function declines and is lost
- Single gene disorders (MODY)
  - "Unmasked" by increased insulin resistance of puberty or increasing fat mass as people enter their 3rd decade of life

**Clues to "Type"**

- History
  - Duration of symptoms/signs
  - Age of child
  - Family history and pedigree
  - Medical history and medications (e.g., CF, Transplant)
- Physical Examination
  - Acanthosis nigricans (marker of insulin resistance)
  - Pubertal status (DM2 more common in puberty and beyond)
- Laboratory testing
  - Basic hospital laboratory
  - Specialized laboratory - Antibody testing, Genetic testing
Acanthosis Nigricans

11-15% of elementary school children have AN

>95% of youth with DM2 have AN

AN is a marker for insulin resistance, not of diabetes

How Common is Childhood Diabetes?

Prevalence

- **DM 1**
  - 1:400 in US (average size elementary school in US)
  - Higher prevalence at higher latitudes
- **DM 2**
  - 1:800 – 1:1000
  - Higher prevalence in high risk ethnic groups
- **Medical not known**
- **MODY**
  - ≤8,000 – 1:10000

Incidence (new cases per year)

- **DM 1** 20/100,000 per year
  - Dependent on age and ethnicity
  - Predominant form of DM in prepubertal children
- **DM 2** 5/100,000 per year
  - Dependent on age and ethnicity
  - Predominant form of DM in children >10 in some ethnic groups

Body Habitus Provides Clue

<table>
<thead>
<tr>
<th>BMI = 95%</th>
<th>BMI &gt; 99%</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 Year Olds</td>
<td>9 Year Olds</td>
</tr>
</tbody>
</table>

Rate of new cases of type 1 and type 2 diabetes among youth ages younger than 20 years, by race/ethnicity, 2002-2005

Source: SEARCH for Diabetes in Youth Study

NHW=non-Hispanic whites; NHB=non-Hispanic blacks; H=Hispanics/Latinos; API=Asian/Pacific Islander Americans; AI=American Indians
Body Habitus Provides a Clue

Medical Diabetes

Prevalence and Incidence Unknown
- Case definitions are problematic
- Often transient but recurrent
- May progress to continuous insulin requirement
- "Unmasking" by underlying disease
- At Santa Rosa Children's Hospital
  - About 1/3 of all in-patient consults are for medical diabetes (CF, oncology, transplant, post-pancreatitis)

Perceptions of Prevalence/Incidence

Affected by:
- Local demographics
- Population(s) served by institution
- Site of observation
  - DM1 more likely to be hospitalized at time of diagnosis
  - DM1 more likely to have recurrent hospitalizations

Newly Diagnosed (Pre-discharge)

- GAD65 Antibodies
- ICA Antibodies
- Free T4 and TSH
- TTG (or other tests for celiac disease)
- Lipid profile (not while in DKA)
- Renal function – BUN, creatinine, microalbuminuria (not while in DKA)

I just counted – I have tested my blood sugar 49,234 times

Hospital Management

- Insulin
- Diet
- Monitoring
- Education
- Activity
- Attitude

Eric – Trained as an EMT and now works as a sales rep for insulin pumps – Diagnosed with diabetes at age 4
### The Patient Is.......

- Newly diagnosed with DM1 or DM2
  - Typically status post stay in PICU (DKA)
- Known to have DM1 or DM2
  - Acutely ill versus “procedure” or “surgery
  - On multiple daily injections (MDI) or pump
- Newly diagnosed “medical” diabetes
  - Already in hospital because of intercurrent illness or due to chemotherapy
  - "Known“ to have medical diabetes

### Deciding on the Dose

- Newly diagnosed – usually require calculation
- If the child already has the diagnosis of diabetes
  - Ask what the home regimen is
  - Resume the home regimen if it sounds reasonable (calculations are the same to determine “reasonable”)
- For medical diabetes, if there are old records, look and see what happened last time.
  - If no information, calculations are a good place to start

### Calculating the Dose

- Start off with the assumption that most children with diabetes in the hospital (but not in DKA) need about 1 unit/kg/day of insulin
  - remember that DKA starting dose in 0.1 unit/kg/hour or ~2.4 units/kg/day
- Typically this is divided as about 40% as a basal (or long acting insulin) and 60% as bolus insulin

### Basal Insulin

- Supports basal metabolic activities (fat and muscle catabolism)
  - Glargine insulin (Lantus) – most common
    - Typically given qd at bedtime
  - Detemir insulin (Levemir)
    - Typically given bid (prebreakfast and predinner)
  - Basal rate on a pump (but the insulin in the pump is rapid acting insulin such as Humalog or Novolog)
    - Programmable, thus permitting variable rate of delivery across the day (e.g., higher rate in the morning, lower rate in the afternoon)

### Bolus Insulin

- Bolus insulin is given to “cover” a bolus of carbohydrate (most typically oral intake)
  - Insulin Lispro (Humalog)
  - Insulin Aspart (Novolog)
  - Insulin Glulisine (Apidra)
- Dosage proportional to the amount of carbohydrate (CHO) intake
- Insulin/Carbohydrate (I/C) ratio may vary dependent on the age of the child and the time of the day
Insulin/Carbohydrate (I/C) ratio may vary:
- The age of the child (young children are more sensitive than older children)
  - 1 unit per 30 grams of CHO in young children
  - 1 unit per 15 grams of CHO in older children
  - 1 unit per 10 grams of CHO in teens
- The time of the day (more insulin resistant in AM)
  - 1 unit per 5 grams of CHO before breakfast
  - 1 unit per 10 grams of CHO before lunch
  - 1 unit per 15 grams of CHO before dinner

Only Rapid Acting Insulin is used in insulin pumps.
- Rapid Acting Insulin is rapidly absorbed and rapidly degraded.
  - It is given shortly before eating (i.e., no waiting needed, and in the hospital, once the tray of food is at the bedside.
  - If a pump is disconnected for longer than 2 hours, the child must get frequent short acting insulin q 2 hours or a basal insulin

**Suzie Martinez**

Thin 8 years old  
No family history of diabetes  
Weight 28 kg  
Estimate need in 1 unit per kg per day (40% basal, 60% bolus)

\[
\begin{align*}
28 \times 0.4 &= 11 \text{ units} \quad \text{Basal (Lantus)} \\
28 \times 0.6 &= 17 \text{ units} \quad \text{Bolus (Analog)}
\end{align*}
\]

Calculated 1 unit will correct the blood sugar by \( X \)
where \( X = 1800/ \text{total daily insulin} \)

Example: Suzie takes 28 units per day (total); therefore 1 unit of insulin will lower her blood sugar by 64 mg/dl (1800/28 = 64)

Does the child have math skills at this level?
Practical Correction (Sliding scale, Algorithm)

### Practical

- **<10 kg**: 1 for every 100 >200 mg/dl
- **10-25 kg**: 1 for every 100 >150 mg/dl
- **26-50 kg**: 1 for every 50 >150 mg/dl
- **>50 kg**: 1 for every 25 >150 mg/dl

Diabetes is an experiential disease

---

The “KISS” Rule

<table>
<thead>
<tr>
<th>1 per 100 starting at 200</th>
<th>1 per 100 starting at 150</th>
<th>1 per 50 starting at 150</th>
<th>1 per 25 starting at 150</th>
<th>1 per 64 starting at 150</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>300</td>
<td>250</td>
<td>200</td>
<td>175</td>
<td>214</td>
</tr>
<tr>
<td>400</td>
<td>350</td>
<td>250</td>
<td>200</td>
<td>???</td>
</tr>
<tr>
<td>500</td>
<td>450</td>
<td>300</td>
<td>225</td>
<td>???</td>
</tr>
</tbody>
</table>

---

The “Easy” Approach at Home

- **Suzie Martinez**
  - **Rapid Acting Insulin Quick Calculator**

<table>
<thead>
<tr>
<th>Blood glucose is:</th>
<th>0</th>
<th>15</th>
<th>30</th>
<th>45</th>
<th>60</th>
<th>75</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;150</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>151-199</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>200-249</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>250-299</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>300-349</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>350-399</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>

Rapid acting insulin is: NOVOLOG or HUMALOG or APIDRA

---

Timing

- Insulin is given **BEFORE meals or snacks containing carbohydrates**
- **Exceptions**
  - Lantus, the long-acting basal insulin
  - Nauseated or ill child, where food intake or retention is unclear
  - Young child (<2 years of age typically) when the intake cannot be reliably predicted
  - Someone forgot to give the insulin before the meal

---

Dr. Tom, despite rumors to the contrary was actually at Camp
Glargine (Lantus) is typically given one time a day in the late evening (e.g., bedtime) but.....
- Can be given in the morning
  - Young child where there is concern about hypoglycemia in the middle of the night
  - Older child with history of frequent nocturnal hypoglycemia or high levels of physical activity in the evening
- Can be split and given half in the AM and half in the PM

DM 1 and MODY
- Carbohydrates > calories

DM2 and Medical Diabetes on insulin
- Carbohydrates and calories
- DM2 and Medical Diabetes not on insulin
  - Calories > carbohydrates

Hospital diet and schedule versus home diet and schedule
Teachable moments

This “camper” is way too young to be a second year endocrine fellow

Suzie’s Breakfast
- 1 cup of milk (8 oz)
- 1 box of cereal (1/2 cup)
- 1/2 cup of juice (4 oz)
- 2 pancakes with sugar-free syrup
- 1 egg and 2 strips of bacon

How many “carbs” is this?
How many grams of carbohydrate is this?

Overwhelming? Difficult?
- The hospital menus LIST the carbs
- Most children do NOT eat a wide variety of foods at home or when they eat out
- Most families tend to go to the SAME fast food or regular restaurants
- Most chain restaurants have their menus with calories and CHO content ON LINE
- Most families (>80%) have access to computers and can look up almost any food on line – calorieking.com is a reliable resource
Monitoring

Do not lose sight of the goal—monitoring is to provide information that should result in action.

- Typically monitor “in hospital” pre-meals, pre-bedtime and at 2-3 AM
- Sometimes monitor 2 hours post meal or post correction dose to be sure that correction has worked
- Can monitor any time that the child has symptoms or signs of low blood glucose

To Panic or Not to Panic: That is the Nurse’s Question

The blood sugar is 425
- How is the child?
- When did the child last eat?
- When was the child’s last dose of insulin?
- The blood sugar is 35
- Is the child alert/arousable?
- This is a “teachable moment” for the family, the nurse, the medical students and ....

Glycemic variability

Blood glucose will be out of target often. WHY?
- 100 mg/dl = 1 gram per liter
- 5 liters of blood = 5 grams of glucose in blood stream
- Meals are often 60-75 grams of CHO

YOU ALREADY KNOW THIS
D25 = 25 gms/100 cc = 250 mg/ml
25 kg child would get 2cc/kg = 50 cc of D25 = 50 cc of D25 = 12.5 gms
Meals are often 60-75 grams of CHO

Education

- Medical students, residents, pediatric attending
  - Reinforcement of key messages; role modeling; general pediatric and behavioral issues; teachable moments
- Hospital nurses
  - Mechanical skills (injections, glucose monitoring)
  - Role models of parenting skills related to DM management
- Dietician
  - Dietary education; basic integration of insulin and food
  - Age appropriate diet; healthy eating
- Endocrine Fellows and Attendings
  - Diabetes pathophysiology; follow-up activities; diabetes education
- Diabetes Educator(s) – contact through Endocrine on-call
  - Comprehensive diabetes education; integrations of diet, activity and insulin; home management; sick day management, etc.

Diabetes Educators and Dietician

- Picture goes here
Physical activity is to be encouraged in hospital.
Street clothes and “non-ill” behaviors encouraged.
Participation is child-life activity is promoted.
Discontinue IVs and saline locks ASAP.
Leaving the hospital is not an approved activity (unfortunately).

There are only 3 things that a child with diabetes cannot do:
- Cannot be in the US Military
- Cannot be a commercial airline pilot
- Cannot ignore the diabetes

That means that a child with diabetes can do everything else!!!

Children with diabetes can:
- Go to school
  - Take part in self care at school in age appropriate fashion
  - Take part in sports and social activities
- Have friends
- Have children and grandchildren
- Eat a “normal diet” including “sweets”
- The role of the team is figure out how, not if

Children with diabetes, need:
- Good and consistent parenting – buy the books, educate yourself about parenting as well as about diabetes
- Good education – those who are educated have good health insurance and therefore...
- Competent care from a team specializing in childhood diabetes – typically every 3 months
- Support – from extended family, schools, friends
Get involved:
- Advocacy
  - Meet other families with diabetes
  - Keep up on technology, research, politics
- Activities
  - Build positive self image
  - Promote health positive benefits
- Research
  - Diabetes is a “team sport”. If you and your family, and other families like yours, do not participate, there will never be a “Cure” or “Prevention”

Standard order set available in each nursing station

210-235-0732 Pager