Management of Type 1 Diabetes in the Pediatric Patient

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Objectives:
- Discuss United States prevalence of type 1 diabetes (T1D) in the pediatric patient
- Diagnose type 1 diabetes in the pediatric patient
- Differentiate type 1 diabetes from other types of diabetes
- Discuss various options of managing type 1 diabetes in the pediatric patient
- Design a custom treatment plan
- Describe developmental changes from childhood through emerging adulthood
- Discuss transitioning diabetes care from childhood through emerging adulthood

Prevalence of Diabetes in Youth


- Type 1 diabetes (T1DM) is the most common form of DM in youth
- By age 18, 1 in 300 have T1DM
- Incidence T1DM increasing 2-5% per year
- Highest incidence in United States, Europe, United Kingdom, Canada, and New Zealand
- Low incidence in Asia and South America (1 per 1,000,000)
- Prevalence: DM in Youth: 208,000 < age 20
- SEARCH for Diabetes in Youth study:
  - Funded by CDC and NIH
  - 11,244 T1DM ages < 20 and 2,846 T2DM ages < 20
  - 2002-2012 rate of new cases T1DM increase 1.8% per year and 4.8% for T2DM

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4874193/

- Chromosome 6p21
- Concordance for monozygotic twins is 50% and 8% dizygotic
- Variants of Human leukocyte antigen complex (HLA) (genes that provide instructions to make proteins that play a role in immune system)
- Haplotypes that increase risk T1DM: (combination of HLA genes)
  - HLA-DQA1, HLA-DQB1, HLA-DRB1 combination is highest risk for T1DM
  - HLA-DR3 or HLA-DR4 puts Caucasians at high risk
  - HLA-DR 7 put African Americans at risk
  - HLA-DR 9 increase Japanese at high risk
- Mother w T1DM: child risk 1 in 25
- Father w T1DM: child risk 1 in 17
- Child’s risk doubled if parent dx before age 11
- Both partners w T1DM: child risk is 1 in 4-10
- Family members w T1DM have 15 x higher risk than general population
- 1 in 7 w T1DM have type 2 polyglandular autoimmune syndrome
  - Thyroid disease, adrenal insufficiency, other immune disorders
Overlapping Genes with T1DM

<table>
<thead>
<tr>
<th>Gene</th>
<th>Overlapping Diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTPN22</td>
<td>AITD, Crohn disease, MS, RA, SLE</td>
</tr>
<tr>
<td>RG51</td>
<td>Celiac disease</td>
</tr>
<tr>
<td>IL10</td>
<td>Crohn disease</td>
</tr>
<tr>
<td>IL18RAP</td>
<td>Celiac disease</td>
</tr>
<tr>
<td>IFIH1</td>
<td>AITD</td>
</tr>
<tr>
<td>RGS1</td>
<td>Crohn disease</td>
</tr>
<tr>
<td>CCR5</td>
<td>Celiac disease</td>
</tr>
<tr>
<td>IL2</td>
<td>AITD, RA, Celiac disease</td>
</tr>
<tr>
<td>IL7R</td>
<td>MS</td>
</tr>
<tr>
<td>TNFAIP3</td>
<td>RA, SLE</td>
</tr>
<tr>
<td>TAGAP</td>
<td>Celiac disease</td>
</tr>
<tr>
<td>IL2RA</td>
<td>MS, SLE</td>
</tr>
<tr>
<td>SH2B3</td>
<td>Celiac disease</td>
</tr>
<tr>
<td>CLEC16A</td>
<td>MS</td>
</tr>
<tr>
<td>ORMHL3</td>
<td>Asthma</td>
</tr>
<tr>
<td>PTPN2</td>
<td>Celiac disease, Crohn disease</td>
</tr>
<tr>
<td>CD226</td>
<td>MS, RA</td>
</tr>
</tbody>
</table>

Environmental Triggers
- Viral infection: coxsackie B4, congenital rubella, mumps
- Environmental toxins
- Cow's milk formulas

Clinical Presentation for T1DM in Youth
- Broad range of signs and symptoms from very mild to coma
- Polyuria/Secondary enuresis
- Polydipsia
- Polyphagia
- Weight loss
- Fatigue
- Irritability
- Decline in school performance
- Diabetic ketoacidosis

Diagnosis of Diabetes

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Pre Diabetes</th>
<th>Diabetes</th>
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<tbody>
<tr>
<td>Fasting</td>
<td>&lt; 100</td>
<td>100-125</td>
<td>126+</td>
</tr>
<tr>
<td>Postprandial</td>
<td>&lt; 140</td>
<td>140-199</td>
<td>200+</td>
</tr>
<tr>
<td>HbA1c</td>
<td>&lt;5.7</td>
<td>5.7-6.4</td>
<td>6.5%+</td>
</tr>
</tbody>
</table>

- If classic symptoms of hyperglycemia or hyperglycemic crisis or random plasma glucose 200+ mg/dL
- In absence of unequivocal hyperglycemia, diagnosis requires 2 abnormal test results from same sample or in 2 separate test samples
Estimated Average Glucose Values

\[ AG \text{ mg/dL} = 28.7 x A1c - 46.7 \]

Causes of Inaccurate HbA1c
- Hemoglobin variants
- Sickle cell disease
- Pregnancy 2nd or 3rd trim
- Postpartum
- Glucose-6 phosphate dehydrogenase deficiency
- HIV
- Hemodialysis
- Recent blood loss
- Blood transfusion
- Erythropoietin therapy

Other Tests:
- C-peptide (measures insulin production by pancreas)
- Urine or blood ketones
- Autoantibodies associated with T1DM

https://diabetes.diabetesjournals.org/content/54/suppl_2/S52
- Islet Cell Antibodies (ICA): against cytoplasmic proteins in beta cells (positive in 69-90% of people w T1DM)
- Glutamic Acid decarboxylase (GAD-65): (positive in 80% of people w T1DM)
- Insulin autoantibodies IAA: correlates inversely with age
- Insulin autoantibody IA-2A: (positive in 54-75% of people w T1DM)
- Zinc transporter isoform ZnT8: present in most newly dx T1DM but decline in first 4 years
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3903401/
- 2 or more autoantibodies predicts clinical diabetes

Differential Diagnosis
- Type 2 diabetes
- Cystic fibrosis related diabetes (CF-RD)
  - Screening for CF-RD with oral GTT begin age 10
  - HbA1c not recommended
  - Should be treated with insulin
- Monogenic diabetes syndromes
  - All less than 6 months should have immediate genetic testing for neonatal DM
  - DM not characteristic of T1DM or T2DM and occurring in successive generations test for maturity-onset diabetes of the young

<table>
<thead>
<tr>
<th>Gene</th>
<th>Inheritance</th>
<th>Clinical Feature</th>
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</thead>
<tbody>
<tr>
<td>MODY</td>
<td>GCK</td>
<td>Nonprogressive elevated FBG; small rise in 2-h PG level on OGTT, typically does not require tx; microvascular complications rare; stable type of DM</td>
</tr>
<tr>
<td>HNF1A</td>
<td>AD</td>
<td>Large rise in 2-h PG level on OGTT, Progressive insulin secretory defect with presentation in adolescence or early adulthood; lowered renal threshold for glucosuria; sensitive to sulfonylureas</td>
</tr>
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</tr>
<tr>
<td><strong>HNF4A</strong></td>
<td>AD</td>
<td>Progressive insulin secretory defect with presentation in adolescence or early adulthood; may have large birth weight and transient neonatal hypoglycemia; sensitive to sulfonylureas</td>
</tr>
<tr>
<td><strong>HNF1B</strong></td>
<td>AD</td>
<td>Developmental renal disease (typically cystic); genitourinary abnormalities; atrophy of the pancreas; hyperuricemia; gout</td>
</tr>
<tr>
<td><strong>Neonatal diabetes</strong></td>
<td><strong>KCNJ11</strong></td>
<td>AD</td>
</tr>
<tr>
<td><strong>INS</strong></td>
<td>AD</td>
<td>Permanent: IUGR; insulin requiring</td>
</tr>
<tr>
<td><strong>ABCC8</strong></td>
<td>AD</td>
<td>Permanent or transient: IUGR; rarely developmental delay; responsive to sulfonylureas</td>
</tr>
<tr>
<td><strong>6q2 PLAGL1, HYMA1</strong></td>
<td>AD for paternal duplication</td>
<td>Transient: IUGR; macroglossia; umbilical hernia; mechanisms include UPD6, paternal duplication or maternal methylation defect; may be treatable with medications other than insulin</td>
</tr>
<tr>
<td><strong>GATA6</strong></td>
<td>AD</td>
<td>Permanent: pancreatic hypoplasia; cardiac malformations; pancreatic exocrine insufficiency; insulin requiring</td>
</tr>
<tr>
<td><strong>EIF2AK3</strong></td>
<td>AR</td>
<td>Permanent: Wolcott-Rallison syndrome: epiphyseal dysplasia; pancreatic exocrine insufficiency; insulin requiring</td>
</tr>
<tr>
<td><strong>FOXP3</strong></td>
<td>X-linked</td>
<td>Permanent: immunodysregulation, polyendocrinopathy, enteropathy X-linked (IPEX) syndrome: autoimmune diabetes; autoimmune thyroid disease; exfoliative dermatitis; insulin requiring</td>
</tr>
</tbody>
</table>

**Type 1 Diabetes Staging**

<table>
<thead>
<tr>
<th></th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics</td>
<td>Autoimmunity Normoglycemia Presymptomatic</td>
<td>Autoimmunity Normoglycemia Presymptomatic</td>
<td>Hyperglycemia Symptomatic</td>
</tr>
<tr>
<td>Diagnostic Criteria</td>
<td>Multiple autoantibodies No IGT or IFG</td>
<td>Multiple autoantibodies Dysglycemia IFG and/or IGT</td>
<td>Clinical symptoms Diabetes by standard criteria</td>
</tr>
</tbody>
</table>
Preventing T1DM: TrialNet

[https://www.trialnet.org/our-research/completed-studies](https://www.trialnet.org/our-research/completed-studies)

- **Pathway to Prevention study:**
  - Free risk screening in United States for T1DM if:
    - age 2.5-45 yrs and have parent, child, sibling w T1DM
    - age 2.5-20 and have aunt/uncle, cousin, grandparent, niece/nephew, or half-sibling w T1DM
    - not been dx w T1DM

- **Abatacept**
  - Has been shown to slow down stage 3 T1DM
  - Currently enrolling for stage 1 T1DM
  - Age 6-45
  - 2+ T1DM related autoantibodies
  - Never have had a live vaccine in past 3 months
  - Not be pregnant

- **Hydroxychloroquine**
  - A Drug FDA approved for 60 years to treat rheumatoid arthritis and lupus
  - Testing to see if it can prevent or slow down stage 1 to abnormal glucose
  - Age 3+
  - 2+ T1DM related autoantibodies
  - Not be pregnant

  - an FcR non-binding humanized monoclonal anti-CD3 antibody
  - delays clinical dx T1DM avg 2 yrs
  - 7 year study: double-masked, placebo-controlled, randomized trial: N=76 (55 less than 18)
  - Multiple positive antibodies and abnormal glucose
  - Placebo group: 72% developed T1DM
  - Treatment group: 43%

**Treatment Plan for T1DM in Youth**

- Must be custom to the patient/family
- Culturally sensitive
- Develop-mentally appropriate
- Patient/family must be able to implement plan
- Family involvement is vial
• Must have expert health care provider team
  o Medical providers
  o Diabetes self-management educators
  o Dietitian
  o Psychosocial/ mental health support

Unique Aspects of Care of T1DM in Youth
• Physical growth
• Sexual maturation
• Ability to provide self-care
• Supervision in child care and school
• Neurologic vulnerability to hypoglycemia and hyperglycemia
• Family dynamics
• Developmental stages

Nutrition Therapy
• Individualized plan
• Initial education then annually
• Counting carbohydrate

![Sample label for Macaroni & Cheese](image)
Total Available Glucose

- 100% of carbohydrate grams
- 50-60% of protein grams
- 10% of fat grams

Disordered Eating

https://care.diabetesjournals.org/content/33/3/495

- Screen for eating disorders between ages 10 and 12
- 15-30% of adolescents w T1DM have an eating disorder
- Adolescent girls w T1DM are twice as likely to have disordered eating compared to those without T1DM
- Eating disorders increase risk of retinopathy 3-fold
- Risk factors for disordered eating
  - Female
  - History of dietary restraint
  - Low self-esteem: effect of DM on self-image and family interaction
  - Depression and difficulty coping with DM
  - Disturbed family function

Diabetes Eating Problem Survey-Revised

Items are answered on a 6-point Likert scale: 0=never; 1=rarely; 2=sometimes; 3=often; 4=usually; 5=always.

- Losing weight is an important goal to me
- I skip meals and/or snacks
- Other people have told me that my eating is out of control
- When I overeat, I don’t take enough insulin to cover the food
- I eat more when I am alone than when I am with others
- I feel that it’s difficult to lose weight and control my diabetes at the same time
- I avoid checking my blood sugar when I feel like it is out of range
- I make myself vomit
- I try to keep my blood sugar high so that I will lose weight
- I try to eat to the point of spilling ketones in my urine
- I feel fat when I take all of my insulin
- Other people tell me to take better care of my diabetes
- After I overeat, I skip my next insulin dose
- I feel that my eating is out of control
- I alternate between eating very little and eating huge amounts
- I would rather be thin than to have good control of my diabetes

Exercise

- Positively affects insulin sensitivity, physical fitness, strength building, weight management, mood, self-esteem
- 60 min moderate to vigorous-intensity aerobic activity daily
- Vigorous muscle-strengthening and bone-strengthening activities 3 days week
- Pre-exercise BG goals: 90-250 mg/dL
- Accessible carbohydrate
- Frequent BG monitoring before, during and after exercise
- Learning how exercise impacts BG
- Common to have initial rise in BG after exercise followed by reduced BG and hypoglycemia during the night
- Custom amount of carbohydrate for exercise
Treatment for T1DM in youth

- Majority of youth w T1DM should be treated with intensive insulin regimens
- All youth with T1DM should monitor BG 6-10 times daily: premeal, prebedtime and as needed
  - Exercise
  - Driving
  - Symptoms of hypoglycemia
  - Illness
- Continuous glucose monitoring should be considered
- Automated insulin delivery systems reduce hypoglycemia and improve glycemic control (if used correctly)

Glycemic Targets for most youth with T1DM

- Before meals: 90-130 mg/dL
- Bedtime/overnight: 90-150 mg/dL
- HbA1c target < 7.5%
- Targets need to be individualized based on risk/history of hypoglycemia
- Check postprandial glucose if discrepancy between HbA1c and premeal blood glucose

Initiating Insulin Therapy

1. Calculate total daily dose: 0.4-1 unit per kg
2. Divide the total daily dose into basal and bolus (usually 50%/50%)
   - More active youth will need less basal and more bolus
3. Calculate an insulin to carbohydrate ratio
   - 450 ÷ total daily dose = initial insulin to carbohydrate ratio (ICR)
4. Calculate a correction/sensitivity factor
   - 1700 ÷ total daily dose = initial correction/sensitivity factor (CF/SF)
5. Choose a target blood glucose

- May need different carb ICR, CF/SF, and target BG for different times of the day
- May need to give rapid acting insulin with snacks
- Give rapid acting insulin 15-20 before eating unless BG low normal
- May need to divide the basal insulin into am/pm doses depending on the brand name and dose
Honeymoon

- At diagnosis, exogenous insulin requirements are large
- After hyperglycemia, ketosis/acidosis is corrected, remaining beta cells recover and produce insulin
- Duration of honeymoon is variable: early diagnosis and good BG control helps to prolong honeymoon

Diabetes Insulin Calculator for Kids [https://www.uwhealthkids.org/type-1-diabetes-diabetic/gadgets-and-apps/40409](https://www.uwhealthkids.org/type-1-diabetes-diabetic/gadgets-and-apps/40409)

**INSULIN**

**RAPID ACTING**

<table>
<thead>
<tr>
<th>Units/Kg/D</th>
<th>Patient</th>
<th>Vial</th>
<th>Pen</th>
<th>Penfill/cartridge</th>
<th>Dispose after</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>Conditioned athlete, honeymoon phase</td>
<td>Yes 1000 units/10mL</td>
<td>Fiasp Flextouch</td>
<td>No</td>
<td>28 days</td>
</tr>
<tr>
<td>0.6</td>
<td>Motivated exerciser, woman in 1&lt;sup&gt;st&lt;/sup&gt; phase follicular cycle</td>
<td>Yes 1000 units/10mL</td>
<td>Fiasp Flextouch</td>
<td>No</td>
<td>28 days</td>
</tr>
<tr>
<td>0.7</td>
<td>Women in luteal phase or 1&lt;sup&gt;st&lt;/sup&gt; trimester preg, adult mildly ill with virus, child starting puberty</td>
<td>Yes 1000 units/10mL</td>
<td>Novolog FlexPen</td>
<td>Penfill for NovoPen Echo 0.5 u increments max 30</td>
<td>28 days</td>
</tr>
<tr>
<td>0.8</td>
<td>Women in 2&lt;sup&gt;nd&lt;/sup&gt; trimester preg, adult with severe infection</td>
<td>Yes 1000 units/10mL</td>
<td>Novolog FlexPen</td>
<td>Penfill for NovoPen Echo 0.5 u increments max 30</td>
<td>28 days</td>
</tr>
<tr>
<td>0.9</td>
<td>Women in 3&lt;sup&gt;rd&lt;/sup&gt; trimester preg, adult with bacterial infection</td>
<td>Yes 1000 units/10mL</td>
<td>Novolog FlexPen</td>
<td>Penfill for NovoPen Echo 0.5 u increments max 30</td>
<td>28 days</td>
</tr>
<tr>
<td>1.0</td>
<td>Women at term preg, adult with severe bacterial infection or illness, child at peak puberty</td>
<td>Yes 1000 units/10mL</td>
<td>Novolog FlexPen</td>
<td>Penfill for NovoPen Echo 0.5 u increments max 30</td>
<td>28 days</td>
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<tr>
<td>1.5-2.0</td>
<td>Child at peak puberty who is ill</td>
<td>Yes 1000 units/10mL</td>
<td>Novolog FlexPen</td>
<td>Penfill for NovoPen Echo 0.5 u increments max 30</td>
<td>28 days</td>
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<tr>
<td>Lispro U-200</td>
<td>Humalog U-200</td>
<td>No</td>
<td>Humalog KwikPen U-200</td>
<td>No</td>
<td>28 days</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------</td>
<td>----</td>
<td>-----------------------</td>
<td>----</td>
<td>---------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 u increment Max 60 3mL/600 units/pen 2 pens/box = 1200</td>
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</tbody>
</table>

**SHORT ACTING**

<table>
<thead>
<tr>
<th>Generic Name</th>
<th>Brand Name</th>
<th>Vial</th>
<th>Pen</th>
<th>Penfill/cartridge</th>
<th>Dispose after</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular U-100</td>
<td>Humulin R U-100 Novolin R Relion R</td>
<td>Yes 1000 units/10mL</td>
<td>No</td>
<td>No</td>
<td>31 days</td>
</tr>
</tbody>
</table>

**INTERMEDIATE ACTING**

<table>
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<tr>
<th>Generic Name</th>
<th>Brand Name</th>
<th>Vial</th>
<th>Pen</th>
<th>Penfill/cartridge</th>
<th>Dispose after</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPH</td>
<td>Humulin N 1 u increment max 60 3mL/300 units/pen 5 pens/box = 1500</td>
<td>No</td>
<td>Vial 31 days Pen 14 days</td>
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<td></td>
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</table>

**LONG ACTING**

<table>
<thead>
<tr>
<th>Generic Name</th>
<th>Brand Name</th>
<th>Vial</th>
<th>Pen</th>
<th>Penfill/cartridge</th>
<th>Dispose after</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basiglar</td>
<td>Basiglar</td>
<td>No</td>
<td>Basiglar KwikPen 1 u increment Max 80 3mL/300 units/pen 5 pens/box = 1500</td>
<td>No</td>
<td>28 days</td>
</tr>
<tr>
<td>Degludec</td>
<td>Tresiba U-100</td>
<td>No</td>
<td>Tresiba FlexTouch 1 u increments Max 80 3mL/300 units/pen 5 pens/box = 1500</td>
<td>No</td>
<td>8 weeks</td>
</tr>
<tr>
<td>Degludec U-200</td>
<td>Tresiba U-200</td>
<td>No</td>
<td>Tresiba FlexTouch U-200 2 u increments Max 160 3mL/600 units/pen 3 pens/box = 1800</td>
<td>No</td>
<td>8 weeks</td>
</tr>
<tr>
<td>Brand Name</td>
<td>Vial</td>
<td>Pen</td>
<td>Penfill/cartridge</td>
<td>Dispose after</td>
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<td>------------</td>
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<td></td>
</tr>
<tr>
<td>Detemir</td>
<td>Yes 1000 units/10mL</td>
<td>Levemir FlexTouch 1 u increments Max 80 3mL/300 units/pen 5 pens/box = 1500</td>
<td>No</td>
<td>42 days</td>
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</tr>
<tr>
<td>Glargine</td>
<td>Yes 1000 units/10mL</td>
<td>Lantus Solostar 1 u increments Max 80 3mL/300 units/pen 5 pens/box = 1500</td>
<td>No</td>
<td>28 days</td>
<td></td>
</tr>
<tr>
<td>Glargine U-300</td>
<td>No</td>
<td>Toujeo Solostar 1 u increments Max 80 1.5 mL/450 units/pen 3 pens/box = 1500</td>
<td>No</td>
<td>28 days</td>
<td></td>
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</tbody>
</table>

**COMBINATION**

<table>
<thead>
<tr>
<th>Generic Name</th>
<th>Brand Name</th>
<th>Vial</th>
<th>Pen</th>
<th>Penfill/cartridge</th>
<th>Dispose after</th>
</tr>
</thead>
<tbody>
<tr>
<td>50% NPL, 50% Lispro</td>
<td>Humalog Mix 50/50</td>
<td>Yes 1000 units/10mL</td>
<td>Humalog KwikPen 50/50 1 u increments Max 80 3mL/300 units/pen 5 pens/box = 1500</td>
<td>No</td>
<td>Vial 28 days  Pen 10 days</td>
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<tr>
<td>75% NPL, 25% Lispro</td>
<td>Humalog Mix 75/25</td>
<td>Yes 1000 units/10mL</td>
<td>Humalog KwikPen 75/25 1 u increments Max 80 3mL/300 units/pen 5 pens/box = 1500</td>
<td>No</td>
<td>Vial 28 days  Pen 10 days</td>
</tr>
<tr>
<td>50% NPH, 50% Regular</td>
<td>Humulin 50/50</td>
<td>Yes 1000 units/10mL</td>
<td>No</td>
<td>No</td>
<td>31 days</td>
</tr>
<tr>
<td>70% NPH, 30% Regular</td>
<td>Humulin 70/30 Novolin 70/30 Relion 70/30</td>
<td>Yes 1000 units/10mL</td>
<td>Humulin 70/30 Kwikpen 1 u increments Max 60 3mL/300 units/pen 5 pens/box = 1500</td>
<td>No</td>
<td>Vial 31 days  Pen 10 days</td>
</tr>
<tr>
<td>70% NPL, 30% Regular</td>
<td>Novolog Mix 70/30</td>
<td>Yes 1000 units/10mL</td>
<td>Novolog Mix 70/30 FlexTouch 1 u increments Max 60 3mL/300 units/pen 5 pens/box = 1500</td>
<td>No</td>
<td>Vial 28 days  Pen 28 days</td>
</tr>
<tr>
<td>70% degludec; 30% aspart</td>
<td>Ryzodeg 70/30</td>
<td>No</td>
<td>Ryzodeg 70/30 FlexTouch 1 u increments Max 80 3mL/300 units/pen 5 pens/box = 1500</td>
<td>No</td>
<td>28 days</td>
</tr>
</tbody>
</table>
Insulin Pump Therapy

**Insulin Pumps on US Market approved for children**
- Medtronic 670G
- Tandem T-slim
- OmniPod

**Hybrid Closed Loop: MiniMed 670G**
- Auto Mode
- No SF needed
- Bolus for CHO
- Suspend before low
- Guardian sensor 3
- Age 7 +
- May not be safe if less than 8 units/day

**Insulin Pump Advantages vs Disadvantages**

**Advantages**
- Delivers short/rapid acting
- More closely matches physiologic needs
- Reduced variation in absorption
- Improved glycemic control, Reduced hypoglycemia
- Improved quality of life and flexibility

**Disadvantages**
- Risk DKA if interruption of insulin delivery
- Potential site infection
- Cost

**Candidate Selection**
- Desires insulin pump
- Check BG frequently
- Able to operate pump
- Able to afford pump
- Able to troubleshoot
- Works with medical team
- Hypoglycemia
- Busy schedule
- Athletes
- Dawn phenomenon
- Elevated HbA1c despite best efforts
- Gastroparesis
Pre Pump Education
- Carbohydrate counting
- Insulin to carbohydrate ratio
- Sensitivity factor
- Sick day management
- Prevention of DKA / ketone testing
- Hypoglycemia treatment
- BG testing / BG goals / record keeping

Calculating Pump Settings

Total Daily Pump Dose
- Method 1: Prepump dose x .75%
- Method 2: Kg x 0.5 or Lb x 0.23

Clinical Considerations
- Average values from methods 1 & 2
- Frequent hypoglycemia: start at lower dose
- Hyperglycemia, ↑HbA1c, preg: start higher dose

Single Basal Rate
- Pump total daily dose x 0.5 ÷ 24 hrs or Pump total daily dose ÷ 48

Carbohydrate Ratio
- 450 ÷ TDD
- Alternate methods:
  - 6 x wt. in kg ÷ TDD or 2.8 x wt. in lb ÷ TDD
  - Fixed Meal Bolus = TDD x 0.5 ÷ 3 equal meals
  - Continue existing CR from MDI regimen

Sensitivity/Correction Factor
- 1700 ÷ Pump TDD

Other Pump Settings
- Target blood glucose
- Active insulin time
- Special settings
  - Auto off
  - Variable bolus
  - Reminders
Troubleshooting Hyperglycemia

• Insulin
  o Loss of potency
  o Wrong insulin in pump

• Infusion set
  o Bent catheter
  o Air in tubing
  o Infusion site problem

• Insulin pump
  o Programming error
  o Pump malfunction

• Behavior
  o Missed bolus
  o Bolused after eating
  o Did not correct
  o Miscount CHO

BG > 250 mg/d: take correction bolus via pump. Recheck BG in 1 hour. If BG not decreasing then check ketones and....

Negative Ketones

• Inject insulin using a syringe: the dose according to the correction factor
• Drink 8 ounces of sugar-free fluids every 30 minutes
• Recheck BG in 1 hour
• If the BG does not decrease, follow the steps in the positive ketones column

Positive Ketones

• Using a new vial of insulin, inject insulin with a syringe: the dose according to the correction factor
• Change the entire infusion set/reservoir using the new insulin
• Recheck BG in 1 hr.
• Drink sugar-free fluids
• If BG does not decrease, contact healthcare provider/go to ER

Discontinuing Pump

• Give basal insulin several hours before disconnecting insulin pump
• Or give basal insulin and a rapid-acting insulin at the time of disconnection
• Check BG every 3-4 hours until stable
• Correct hyperglycemia with rapid acting insulin being careful not to stack the insulin

Continuous Glucose Monitoring

Benefits

• Reduces risk for hypoglycemia
• Reduces risk for extreme hyperglycemia
• Reduces risk for wide BG fluctuations
• Behavior modification / learning
BG< 70 mg/dl: DM vs. Non DM

<table>
<thead>
<tr>
<th>No Diabetes</th>
<th>T1DM or low C-Peptide</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Insulin levels drop</td>
<td>- Insulin levels high</td>
</tr>
<tr>
<td>- Glucagon secreted</td>
<td>- Glucagon not secreted</td>
</tr>
<tr>
<td>- Epinephrine release</td>
<td>- Epinephrine release</td>
</tr>
<tr>
<td>- Norepinepherine</td>
<td>- Norepinepherine</td>
</tr>
<tr>
<td>- Cortisol release</td>
<td>- Cortisol release</td>
</tr>
<tr>
<td>- Growth hormone</td>
<td>- Growth hormone</td>
</tr>
<tr>
<td>- Neurotransmitters</td>
<td>- Neurotransmitter</td>
</tr>
</tbody>
</table>

- 20% of T1DM will die from hypoglycemia
- 40% of T1DM will have severe hypo if duration of > 15 years
- Annual rate of severe hypoglycemia requiring emergency medical services: 7.1%
- Mortality rate 1 year after severe hypoglycemia T1 & T2 combined = 17%

Hypoglycemia Symptoms
- Shaky
- Sweating
- Weakness
- Irritable/confusion
- Lethargy/unconsciousness

Tx of Mild Hypo: 15 grams simple CHO
- 4 glucose tablets
- 4 pieces hard candy
- 4 starburst
- 15 skittles
- ½ cup sweet drink/juice
- 1 tbsp honey, syrup, sugar
Severe Hypoglycemia Treatment: Glucagon
- Cause glycogen to be converted into glucose
- 1 kit raises BG ~ 50 mg/dl
- 1 Kit has 1 mg
- Given SC, IM, or IV
- 1 mg for child > 4
- ½ mg for child < 4
- Sites same as insulin
- Push needle in all way

Mini Dose Glucagon
- Pt unable to swallow CHO but is awake & alert with BG < 80 mg
- 2 “units” for 1 yo
- 1 “unit” per year of age for 2 years & older
- Max 15 “units”
- If not above 80 mg/dL in 30 min, double the dose (max 30)

Glucagon nasal powder (Baqsimi) 3 mg one time use

Beta-hydroxybutyrate: NovaMax
0.6 – 1.5 = call MD
> 1.5 = go
## Development Tasks for Youth with T1DM

<table>
<thead>
<tr>
<th>Age</th>
<th>Tasks</th>
</tr>
</thead>
</table>
| Infant 0-1 yr | Infants have variable activity and appetite, so caregiver needs to have flexible care regimen  
Differentiate sx hypoglycemia from normal behavior  
Needs frequent feeding, monitoring and injections  
Caregivers will need to train other potential caregivers |
| Toddler 1-3 yr | Differentiate sx hypoglycemia from normal behavior  
Inconsistent eating as child begins to feed self  
Give child choices in food, injection and fingerstick sites  
Encourage child to report if feels “funny”  
Allow child to help with diabetes activities if desired |
| Preschool 3-5 yr | Teach child to report feelings of hypoglycemia  
Teach child what to eat when low  
Stress to child that finger sticks, injections, pump and sensor sites are not a punishment  
Teach teachers/caregivers about diabetes care, especially hypoglycemia recognition and treatment  
Invite child to perform simple tasks such as putting blood on strip  
Involve child in menu planning |
| School age 5-12 yr | Teach school personnel involved with the child’s care  
Optimize BG control to prevent school absences  
Parents should learn to adjust insulin doses based on patterns  
Child should be involved in sports and social events  
Child should begin to perform diabetes self-care skills as desired under adult supervision  
Too much self-care too soon may cause diabetes burnout |
| Adolescents | Adolescent is striving towards independence / parents may have a hard time letting go  
Friends are important, behavior may be influenced by peers  
May want to hide diabetes from others  
Many hormonal changes which causes insulin resistance  
May make of BG readings  
Allowing self-care skills to be performed when not in the presence of caregivers, but checked by caregivers to see if it is being done  
Need counseling on drugs, alcohol, and sex |
| Adults | 4 major aspects: Marriage, Family, Employment, Finances  
Intimate relationships  
Need for preconception/pregnancy counseling |

### Psychosocial

- At diagnosis and follow up appointments assess patient/family psychosocial issues that may impact diabetes management and refer if needed
- Assess for diabetes related distress beginning age 7-8
- Allow alone time with healthcare provider beginning age 12 or when appropriate
- At puberty, preconception counseling should be discussed at each visit
- Assess for eating disorders between ages 10 and 12

Diabetes Family Conflict Scale

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4930361/

<table>
<thead>
<tr>
<th>During the past month, I have argued with my parents about:</th>
<th>Almost never</th>
<th>Sometimes</th>
<th>Almost always</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remembering to give shorts or to bolus (pump)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taking more or less insulin depending on results</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remembering to check blood sugars</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remembering clinic appointments</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Giving shots or boluses (pump)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meals and snacks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Results of blood sugar monitoring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The early signs of low blood sugar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>What to eat when away from home</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making appointments with dentists and doctors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telling teachers about diabetes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telling friends about diabetes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrying sugar/carbs for reactions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School absences</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telling relatives about diabetes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotating injection sites or infusion sets (pump)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changes in health (like weight or infections)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logging blood sugar results</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Blood Glucose Monitoring Communication Questionnaire:

https://pdfs.semanticscholar.org/34af/e62171e384ce2fd2a5bfd1e886e2c80ab186.pdf

<table>
<thead>
<tr>
<th>Youth BGMC questionnaire: during the past week</th>
<th>Almost never</th>
<th>Sometimes</th>
<th>Almost always</th>
</tr>
</thead>
<tbody>
<tr>
<td>When my blood sugar is high, I get upset thinking that I will be blamed for something I ate</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>When my blood sugar is high, I feel scared</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>When my blood sugar is high, I feel frustrated</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I am upset when I have a high blood sugar</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I feel frustrated when I have a low blood sugar</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>When my blood sugar is high, I feel guilty</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>When my blood sugar is low, I feel scared</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parent BGMC questionnaire: during the past week</th>
<th>Almost never</th>
<th>Sometimes</th>
<th>Almost always</th>
</tr>
</thead>
<tbody>
<tr>
<td>When my child’s blood sugar is high, I get upset thinking that my child ate sweets (candy bar, ice cream, etc)</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>When my child’s blood sugar is high I feel scared</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>When my child’s blood sugar is high I feel frustrated</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I feel upset when my child has a high blood sugar</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I feel angry when my child’s blood sugar is high</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I feel frustrated when my child has a low blood sugar</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
When my child’s blood sugar is high, I feel guilty | 1 | 2 | 3
When my child’s blood sugar is low, I feel scared | 1 | 2 | 3

Problem Areas in Diabetes-Teen (PAID-T)


Take the total score and multiply by 1.25 to get the total score out of 100. A score of 40 or higher is severe diabetes distress.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Not having clear and concrete goals for diabetes care?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Feeling discouraged with your diabetes treatment plan?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Feeling scared when you think about living with diabetes?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Uncomfortable social situations related to your diabetes care (e.g. people telling you what to eat)?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Feelings of deprivation regarding food and meals?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Feeling depressed when you think about living with diabetes?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Not knowing if your mood or feelings are related to your diabetes?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Feeling overwhelmed by your diabetes?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Worrying about low blood glucose reactions?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Feeling angry when you think about living with diabetes?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Feeling constantly concerned about food and eating?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Worrying about the future and the possibility of serious complications?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Feeling of guilt or anxiety when you get off track with your diabetes management?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Not “accepting” your diabetes?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Feeling unsatisfied with your diabetes physician?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Feeling that diabetes is taking up too much of your mental and physical energy every day?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Feeling alone with your diabetes?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Feeling that your friends and family are not supportive of your diabetes management efforts?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Coping with complications of diabetes?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
Feeling “burned out” by the constant effort needed to manage diabetes?

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
</table>


- Feeling that my teen and I just don’t work well together when it comes to diabetes.
- Feeling that I can’t trust my teen to take good care of his/her diabetes.
- Worrying that my teen will ignore or forget diabetes if I don’t keep reminding him/her.
- Feeling that trying to help my teen with his/her diabetes is always a battle.
- Feeling that my teen doesn’t do enough to manage his/her diabetes.
- Frustrated because my teen ignores my suggestions about diabetes.
- Feeling uncertain about how to motivate my teen to take better care of his/her diabetes.
- Worrying that my nagging about diabetes is hurting my relationship with my teen.
- Feeling unappreciated for all the ways I try to help my teen manage diabetes.
- Feeling that diabetes is taking up too much of my mental and physical energy everyday.
- Feeling that no one notices that diabetes is hard on me, not just on my teen.
- Worrying that others will blame me if my teen’s diabetes is not well-controlled.
- Frustrated by the lack of understanding and support for diabetes I get from friends and family members.
- Frustrated that I am the only one who takes responsibility for helping my teen manage diabetes.
- Worrying about my teen’s low blood sugars when he/she is away from home.
- Worrying that my teen will soon leave home and I cannot protect him.
- Worrying about my teen’s low blood sugars when he/she is sleeping.
- Concerned that my teen is not prepared to deal with the world of insurance and doctors once he/she is an adult.
- Worrying that my teen doesn’t have the right doctors for him/her.
- Worrying that my teen doesn’t get all of the expert medical help he/she needs.

Preconception Counseling

- Provide counseling at every visit if youth is of childbearing age.
- Resources directed to teens is available through ADA.

Assess for Other Autoimmune Conditions if suspected

- Thyroid: check soon after dx then every 1-2 years.
  - antithyroid peroxidase, antithyroglobulin antibodies, and TSH.
- Celiac: check soon after dx then every repat within 2 years then again after 5 years, more often if sx or family hx.
  - IgA tissue transglutaminase (tTG) antibodies with normal total serum IgA levels.
  - IgG to tTG and deamidated gliadin antibodies if IgA deficient.
- Other autoimmune conditions: check if suspected.
  - Addison
  - Autoimmune hepatitis
  - Autoimmune gastritis
  - Dermatomyositis
  - Myasthenia gravis.

Managing Cardiovascular Risk Factors

- Check BP at each visit: if high: check on 3 different visits.
  - Treat dietary modification, exercise, weight control.
Consider pharmacologic tx if lifestyle modification does not correct and BP is > 95\textsuperscript{th} percentile for age, sex and height

- ACEI or ARB initial tx (counsel regarding teratogenic effects)
- Goal: BP < 90\textsuperscript{th} percentile for age, sex, and height

- **Fasting lipid profile age 10+**
  - If normal, repeat every 3-5 years
  - If elevated: optimize BG control and medical nutrition therapy
  - Beginning a statin: age 10+ who does not respond to therapeutic lifestyle modification
  - Goal: LDL < 100 mg/dL

### Assessing for Microvascular Complications

- **Nephropathy**
  - Annual screening for albuminuria with random sample
  - After 5 yrs from dx: Spot albumin-to-creatinine ratio considered at puberty or age > 10 which ever earlier
  - If albumin-to-creatinine ratio >30 mg/g, optimize BG and BP
  - Treat with ACEI or ARB if albumin-to-creatinine ratio >30 mg/g for 2 of 3 samples with 6 month intervals

- **Retinopathy**
  - Initial dilated comprehensive eye exam with duration T1DM 3-5 yrs and age 10+ or at puberty
  - Follow up exams every 1 year unless advised by eye care professional for every 2 year exams

- **Neuropathy**
  - After duration of T1DM of 5 years: consider comprehensive foot exam at puberty or age 10+ whichever comes first