## INSULIN ALGORITHM FOR TYPE 2 DIABETES MELLITUS IN CHILDREN¹ AND ADULTS

### Treatment Naive¹;
- Symptomatic;
- FPG ≥ 260 mg/dL in adults or A1C ≥ 10%, ketoacidosis or recent rapid wt loss in children

### Oral Agent Failure;
- A1C above target but < 8.5%

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- A1C ≥ 8.5%

### Options ²⁻³
1. Once-daily Insulin
2. Multi-dose Insulin (pediatric)
3. Intensive Insulin Management

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### Footnotes
1. Combining metformin with insulin therapy has been shown to result in less weight gain and better glycemic control with lower insulin requirements
2. Consider simultaneous combination oral agent therapy
3. Combining metformin with insulin therapy has been shown to result in less weight gain and better glycemic control with lower insulin requirements
4. Continue combination oral agent therapy + sulfonylurea
5. Continue metformin (+ 3rd oral agent); probably discontinue sulfonylurea
6. PCP may decide to “ease” patient with poor beta-cell reserve into insulin therapy initially with QDI

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### Once-daily Insulin Therapy (QDI)

**At bedtime (HS):** NPH (pen/vial) or q daily Long-acting insulin (LAI) (pen/vial) or Before supper (ACS): NPH mix with Short-acting insulin (SAI) (2:1 ratio or sliding scale⁷) (vial) or premix 70/30 or 75/25 (pen/vial)

### Starting dose⁸:
- 0.1–0.25 units/kg; or 6–10 units for elderly/thin/complicated patients
- Escalate dose every 2–3 days to attain SMBG/FPG target values; consider HS SMBG in adjusting dose of ACS mix/premix (SAI component)

### Suggested titration schedule⁹
- If fasting SMBG
  - >180 mg/dL + 6 units
  - 141–180 mg/dL + 4 units
  - 121–140 mg/dL + 2 units
  - 100–120 mg/dL + 1 unit
  - <80 mg/dL - 2 units

### Glycemic Targets
- Not Met After 6–12 Weeks
- Met Follow A1C every 3–6 months and Adjust Regimen to Maintain Glycemic Targets (Inulin Requirement May Decrease as A1C improves)

### Multi-dose Insulin Therapy (MDI)⁰⁻¹⁰
- **2 shots**
  - Split mix NPH + Short-acting insulin (SAI) (vial)
    - (2:1 ratio AM, 1:1 ratio PM; or SAI sliding scale⁷)
  - or premix 70/30; 75/25 or 50/50 (pen/vial)
- **3 shots**
  - (especially if nocturnal hypoglycemia)
  - SAI: ACB and ACS sliding scale⁷ (pen/vial)
- NPH: ACB and HS (pen/vial) or LAI: q daily (pen/vial)

### Starting dose⁸:
- 0.3–0.5 units/kg/day (or if current dose > 0.5 units/kg/day, take 80% of QDI dosage) divided 2/3 as NPH/LAI; 1/3 as SAI; titrate to achieve glycemic targets

### Intensive Diabetes Management — Physiologic Insulin Delivery¹⁰
1. 1:1 basal:bolus ratio SQ
   - Basal: NPH at ACB, ACS or HS (or QID) (pen/vial); or Long-acting insulin (LAI) q daily (pen/vial)
   - Bolus: Short-acting insulin (SAI) at each meal (especially Lispro/Aspart) (pen/vial)

### Premeal insulin dose includes:
- 1. Insulin to cover carbohydrate intake
- 2. Additional insulin to correct for high SMBG (1 unit SAI lowers PG [mg/dL] by approximately 1500/TDI for Regular; 1800/TDI for Lispro/Aspart)

### Starting dose⁸:
- 0.3–0.5 units/kg/day (or if current dose > 0.5 units/kg/day, take 80% of total NPH dosage as glargine [basal]; bolus dose=80% of glargine dose divided tid)

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### Pramlintide¹¹,¹²
Consider as adjunct therapy to insulin in patients unable to stabilize post-prandial glucose.

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### See web site (http://www.texasdiabetescouncil.org) for latest version and disclaimer.
See reverse side for more information. (Page 1 of 6)
INITIATION OF INSULIN THERAPY
FOR TYPE 2 DIABETES MELLITUS IN CHILDREN AND ADULTS:
A SIMPLIFIED APPROACH

**Targets**
- A1c <6.5%
- FPG/SMBG ≤ 110 mg/dL
- 2-hr PPG/SMBG ≤ 140–180 mg/dL

*Individualization is recommended for those with chronic disease states or other comorbidities associated with high risk of hypoglycemic events.

**Treatment Naive:**
- FPG ≥ 260 mg/dL;
- Symptomatic
- Begin Combination Oral Agent Therapy ²

**Strongly Consider Initiation of Insulin Therapy with Glargine (pen/vial) daily³ or NPH (pen/vial) HS⁴**

**Abbreviations**
- FPG: Fasting plasma glucose
- HS: Bedtime
- PPG: Post-prandial plasma glucose
- SMBG: Self-monitored blood glucose
- TDI: Total daily insulin in units

**Beginning Dosage:** 10 units or 0.1–0.25 units/Kg

**Suggested Titration Schedule—Adjust Every 2–3 Days**
- If Fasting SMBG²:
  - > 180 mg/dL Add 6 units
  - If 141–180 mg/dL Add 4 units OR increase by 2 units every 2–3 days to FPG ~ 100 mg/dL
  - If 121–140 mg/dL Add 2 units
  - If 100–120 mg/dL Add 1 unit
  - If < 80 mg/dL Subtract 2 units

**Footnotes**
1. See Insulin Algorithm for Type 2 Diabetes Mellitus in Children and Adults.
2. Usually with an insulin secretagogue (sulfonylurea, repaglinide or nateglinide) and sensitizer (metformin or thiazolidinedione). See Glycemic Control Algorithm.
3. FDA-approved in 2003 for q daily dosing.
4. The pharmacokinetic profile of NPH compared to that of glargine is less predictable, therefore can result in blood sugar variations and increased nocturnal hypoglycemia. Cost of glargine is 1.5–2 times that of NPH. Lispro 75/25 or Aspart 70/30 can be considered at pre-supper adjusting dosage according to HS and fasting SMBG.
5. If daytime hypoglycemia develops, contact healthcare professional.

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WORKSHEET

Advancing to Intensive/Physiologic Basal: Bolus Insulin Therapy

Note: “Analog” = Rapid Acting (Bolus) Analog insulin throughout this document.

A. Conversion from once-daily insulin to intensive/physiologic insulin replacement:

Oral therapy failure: Once-daily glargine was added to the oral regimen and titrated to 30 units per day. How do you add analog insulin if the patient reports the following SMBG values?

<table>
<thead>
<tr>
<th>Case</th>
<th>FPG</th>
<th>2-hr pp Brkft</th>
<th>2-hr pp Lunch</th>
<th>2-hr pp Dinner</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>105</td>
<td>140</td>
<td>140</td>
<td>240</td>
</tr>
<tr>
<td>2</td>
<td>105</td>
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</tr>
<tr>
<td>3</td>
<td>105</td>
<td>190</td>
<td>240</td>
<td>240</td>
</tr>
</tbody>
</table>

Case 1

a. Continue the oral agents (+ sulfonylurea) and 30 units glargine (or NPH)

b. There are 2 approaches for adding analog 10 minutes before a meal:

#1 Arbitrary start: 5 units
   Titrate: Add 2 units every 2 days to reach 2-hr pp goal

#2 Carb-counting 1 unit/50 mg/dL over 2-hr pp goal
   PLUS
   1 unit/15 grams carbohydrate
   Titrate: Add 1 unit/50 mg/dL >2-hr pp goal every 2 days

Cases 2 and 3

As above, but add and titrate analog before each meal where the postprandial glucose is above goal. Also, see part D, below, for more information on how to optimize the use of analog insulin. Re-evaluate each week to be certain that about half of the total daily dose is basal and half is bolus insulin.

B. Conversion from once-daily premix to intensive/physiologic insulin replacement:

Oral therapy failure: Once-daily 70/30 premixed insulin was added and titrated to 30 units per day. The fasting glucose is at goal, but daytime control is poor. How do you convert to physiologic insulin therapy?

a. Basal insulin dose: The first step in the conversion is based on the total dose of intermediate-acting insulin. In this case, the person is taking 21 units of NPH or aspart-protamine insulin (70% x 30 units=21 units). So, give 21 units basal glargine (use “unit-for-unit” conversion for once-daily intermediate regimens.) Remember; do not stop oral agents (+ sulfonylurea) at this time.

b. Bolus insulin dose: There are several ways to start the analog.

i. See Case 1, page 2 (Arbitrary start or Carb-counting)

ii. Begin with the previous dose of fast-acting insulin, divide it before meals and titrate every 2 days. In this case, the person was using 30 units of 70/30 or about 9 units of fast-acting insulin (30% x 30 units=9 units). So give 3 units of analog before each meal and titrate every 2 days as per Case 1.
C. Conversion from twice-daily premix to intensive/physiologic insulin replacement:

Oral therapy failure in an 80 kg person: 70/30 premixed insulin was started and advanced to 60 units per day: 40 units before breakfast and 20 units before dinner. The fasting glucose was at goal, but wide glycemic excursions occurred at other times during the day and night. How do you convert this person to physiologic insulin therapy? There are several approaches. Use whichever method you want.

a. Start over and begin insulin at 0.5 units/kg. Give half as basal insulin and half as analog, divided before meals. In this case, the starting dose would be 40 units per day. Start giving 20 units glargine each morning and about 7 units analog before each meal. Titrate the basal and bolus insulins every 2 days to fasting and 2-hr postprandial goals.

b. Conversion based on current insulin usage:
   
   **Basal dose:** The first step in the conversion is based on the 80% of the total dose of intermediate-acting insulin. In this case, the person is taking 42 units of NPH or aspart-protamine insulin (70% x 60 units = 42 units). When a person is taking multiple doses of intermediate-acting insulin, we give only 80% as glargine. So, give 34 units basal glargine (80% x 42 =~ 34). Remember, do not stop oral agents (+ sulfonylurea) at this time.

   **Bolus insulin dose:** There are several ways to start the analog.
   
i. See Case 1, page 3 (Arbitrary start or Carb-counting)
   
   ii. Begin with the previous dose of fast-acting insulin, divide it before meals and titrate every 2 days. In this case, the person was using 60 units of 70/30 or 18 units of fast-acting insulin (30% x 60 units = 18 units). So, give 6 units of analog before each meal and titrate every 2 days as per Case 1.

c. The “80%-80%” rule: Similar to the above method, but yields an ideal ratio of basal:bolus insulin in one step. The dose of basal glargine will be 80% of the total intermediate insulin, and the analog will be 80% of the glargine dose, divided before meals.

   Basal dose:   =   80% of total intermediate insulin
                =   80% x 42 units      (70% x 60 = 42)
                =   34 units glargine

   Analog dose:=   80% of the glargine dose, divided tid
                 =   80% x 34 units, divided tid
                 =   27 units, divided tid
                 =   9 units aspart or lispro before meals

   Note: Total dose of insulin is conserved and an ideal ratio between basal and bolus will always result with the “80%-80%” method.
D. Optimizing analog insulin use

Tight control of blood glucose requires that the patient participates in the management of their diabetes. This includes monitoring their blood glucose and learning to count carbohydrates or “carb count.” The following material explains how to calculate the dose of analog required to cover a meal and how to add extra analog to correct a hyperglycemic event.

a. Determining the dose of analog insulin to use before a meal

   The “Rule of 500” is used to determine how many grams of carbohydrate 1 unit of analog insulin will cover. When this number is known, then the person can easily give the correct dose of analog by simply counting the grams of carbohydrate they intend to eat at the meal.

   Specifically, 500 divided by the total daily insulin dose (500/TDI) yields the number of grams of carbohydrate that 1 unit of analog will cover. For example, if a person has established that they require about 50 units of insulin per day, then it follows that 1 unit of analog will cover 10 grams of carbohydrate (500/50 = 10). If the person carb counts 140 grams in the dinner meal, then the dose of analog will be 14 units given 10 minutes before eating.

b. Correcting for hyperglycemia

   The “Rule of 1800” is used to determine how much insulin to use to bring a high glucose reading back to goal. Even with tight control, hyperglycemia occurs and people need to be able to correct this situation.

   Specifically, 1800 divided by the total daily insulin dose yields a value indicating how much 1 unit of analog insulin will lower the blood glucose. Thus, if a person uses 90 units of insulin per day, then 1 unit of analog will reduce the blood glucose by 20 mg/dL (1800/90 = 20). *This augment dose of insulin can be used by itself to correct hyperglycemia, or added to the bolus dose if glucose is high before a meal.*

2. Spellman CW, Renda SM, Davis SN. Realizing the Potential of Insulin Therapy in Type 2 Diabetes: A Case Presentation-Based Monograph, presented at the American College of Osteopathic Internists 64th Annual Convention; Chicago, IL (September 30, 2004).
3. www.texasdiabetescouncil.org
**Revised 10-20-05**

**2-shot regimens (continued)**

70% NPH/30% Regular vs. Humalog Mix 75/25™ or Novolog Mix 70/30™


**3-shot Regimens**


**Intensive Insulin Therapy**


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**Reviews/Important Articles:**


**ONCE DAILY INSULIN**

**Morning vs. Bedtime NPH**


**Morning vs. Bedtime Glargine**


**NPH vs. Glargine**


**ONCE DAILY vs. TWICE DAILY REGIMEN**


**MULTIPLE DOSE INSULIN REGIMENS**

**2-shot regimens**

NPH/Regular vs. NPH/short acting analogue therapy